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ABSTRACT

Maintenance methods that can be used equally well in all regions of the country have been developed for the use of asphalt in pavement maintenance. Specific information covering methods, equipment and terminology that applies to the use of asphalt in the maintenance of all types of pavement structures, including shoulders, is provided. In many instances reference is made to other publications of the Asphalt Institute available from any Asphalt Institute office. The addresses of these offices are given on the last pages of this manual. Photographs and drawings are included. (RK)

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ASPHALT IN PAVEMENT MAINTENANCE

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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ASPHALT IN PAVEMENT MAINTENANCE

THE ASPHALT INSTITUTE

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FOREWORD

This manual has been prepared for those who are directly concerned with pavement maintenance. It provides useful and practical information about methods, equipment and terminology that applies to the use of asphalt in the maintenance of all types of pavement structures, including shoulders.

Maintenance of drainage facilities is discussed only to the point where it is directly related to the drainage of the pavement structure itself. Not included in the manual are:

Pavement striping or painting.
Curbs and gutters.
Maintenance of bridges.
Slope paving and erosion control.
Snow removal or snow fences.
Guard rails.
Traffic signs.
Sweeping or cleaning of debris from the pavement.
Care of trees or other vegetation.

In many instances reference is made to other publications of The Asphalt Institute, available from any Asphalt Institute office. The addresses of these offices are given on the last pages of this manual.

Finally, a word of appreciation is due the many persons and agencies who had a hand in the development of this manual. Information on maintenance techniques and equipment was freely furnished by state highway departments, county and city engineering departments, agencies of the federal government, equipment manufacturers, contractors, and many individuals. Also, reviews of the manuscript by knowledgeable engineers helped immeasurably in the production of this publication.

THE ASPHALT INSTITUTE
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Photographs and drawings of equipment used in this publication are for illustration only and do not imply preferential endorsement of any particular make by The Asphalt Institute.

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Chapter I

INTRODUCTION

1.01 SCOPE—This is a how-to-do-it manual, limited to specific information on the use of asphalt in pavement maintenance. Planning, programming, financing and administration of maintenance are beyond its scope. Other publications, one of which is *Street and Urban Road Maintenance,* published by the American Public Works Association*, cover these phases quite well.

Pavement maintenance is a major activity of every highway and street department. Usually, money for maintenance is limited and the maintenance man is called upon to "make one dollar do the work of two." This is not easy.

Large differences in soil types, climate, terrain, traffic and other factors make for greatly varying problems, even within small areas. Some regions are rugged and mountainous while others are fairly smooth and level; some have heavy rainfall, others are semi-arid; some highways and streets must accommodate vehicles carrying coal, ore, logs, or other heavy loads, while others are subjected to only lightweight traffic.

Yet, despite these differences, there are maintenance methods that can be used equally well in all regions. Presenting some of these methods is the purpose of this manual.

1.02 DEFINITIONS—Some of the terms used in this manual are defined here in order that their meanings will be clear.

(1) *Asphalt Concrete*—High-quality, thoroughly-controlled hot mixture of asphalt cement and well-graded, high quality aggregate, thoroughly compacted into a uni-

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form dense mass typified by Asphalt Institute Type IV mixes. (See *Specifications and Construction Methods for Asphalt Concrete and Other Plant-Mix Types,* Specification Series No. 1 (SS-1), The Asphalt Institute.

(2) *Asphalt Emulsion Slurry Seal*—A mixture of slow-setting emulsified asphalt, fine aggregate and mineral filler, with water added to produce slurry consistency.

(3) *Asphalt Fog Seal*—A light application of slow-setting asphalt emulsion diluted with water. It is used to renew old asphalt surfaces and to seal small cracks and surface voids. The emulsion is diluted with an equal amount of water and sprayed at the rate of 0.1 to 0.2 gallon (of diluted material) per square yard, depending on the texture and dryness of the old pavement.

(4) *Asphalt Leveling Course*—A course (asphalt aggregate mixture) of variable thickness used to eliminate irregularities in the contour of an existing surface prior to superimposed treatment or construction.

(5) *Asphalt Overlay*—One or more courses of asphalt construction on an existing pavement. The overlay generally includes a leveling course, to correct the contour of the old pavement, followed by uniform course or courses to provide needed thickness. (Overlays usually are considered construction, not maintenance.)

(6) *Asphalt Pavements*—Pavements consisting of a surface course of mineral aggregate coated and cemented together with asphalt cement on supporting courses such as asphalt bases; crushed stone, slag, or gravel; or on portland cement concrete, brick, or block pavement.

(7) *Asphalt Pavement Structure* — (sometimes called Flexible Pavement Structure)—Courses of asphalt-aggregate mixtures, plus any non-rigid courses between the asphalt construction and the foundation or subgrade. [*See also* (12), (13) and (15) below.]

(8) *Asphalt Prime Coat*—An application of low-viscosity liquid asphalt to an absorbent surface. It is used to prepare an untreated base for an asphalt surface.

The prime penetrates into the base and plugs the voids, hardens the top and helps bind it to the overlying asphalt course. It also reduces the necessity of maintaining an untreated base course prior to placing the asphalt pavement.

(9) *Asphalt Seal Coat*—A thin asphalt surface treatment used to waterproof and improve the texture of an asphalt wearing surface. Depending on the purpose, seal coats may or may not be covered with aggregate. The main types of seal coats are aggregate seals, fog seals, emulsion slurry seals, and sand seals.

(10) *Asphalt Surface Treatments*—Applications of asphaltic materials to any type of road or pavement surface, with or without a cover of mineral aggregate, which produce an increase in thickness of less than one inch.

(11) *Asphalt Tack Coat*—A very light application of liquid asphalt applied to an existing asphalt or portland cement concrete surface. Asphalt emulsion diluted with water is the preferred type. It is used to ensure a bond between the surface being paved and the overlying course.

(12) *Deep-Lift Asphalt Pavement*—An asphalt pavement structure [*see* (7) above] in which the asphalt base course is placed in one or more lifts of 4 or more inches compacted thickness.

(13) *Deep-Strength Asphalt Pavement*—DEEP-STRENGTH® is a term registered by The Asphalt Institute with the U. S. Patent Office. The term DEEP-STRENGTH (also called "mark") certifies that the pavement is constructed of asphalt with an asphalt surface on an asphalt base and in accordance with design concepts established by the Institute. (See latest edition of *Thickness Design* manual (MS-1)).

(14) *Deflection*—The amount of downward vertical movement of a surface due to the application of a load to the surface.

(15) *Full-Depth Asphalt Pavement*—An asphalt

pavement structure [*see* (7) above] in which asphalt mixtures are employed for *all* courses above the subgrade or improved subgrade. A Full-Depth asphalt pavement is laid directly on the prepared subgrade. (The mathematical symbol T_A denotes Full-depth.)

(16) *Mixed-in-Place* (*Road-Mix*)—An asphalt course produced by mixing mineral aggregate and liquid asphalt at the road site by means of travel plants, motor graders, drags, or special road-mixing equipment.

(17) *Pavement*—see *Pavement Structure.* (As used in this manual, the word "pavement" means "pavement structure.")

(18) *Pavement Structure*—All courses of selected material placed on the foundation or subgrade soil, other than any layers or courses constructed in grading operations.

(19) *Plant Mix*—A mixture, produced in an asphalt mixing plant, which consists of mineral aggregate uniformly coated with asphalt cement or liquid asphalt.

(20) *Plant-Mixed Surface Treatments*—A layer, less than one inch thick, of aggregate that is coated with asphalt in a plant. Plant-mixed surface treatments are used extensively for providing skid-resistant surfaces.

(21) *Undersealing Asphalt*—A high softening point asphalt used to fill cavities beneath portland cement concrete slabs and occasionally to correct the vertical alignment by raising individual slabs.

1.03 MAINTENANCE DEFINED—Pavement maintenance is not easy to define. Highway departments agree in general as to what it is but there are some minor differences, chiefly in scope. Some call pavement improvement "maintenance." Others include only the work which keeps the pavement in its as-constructed condition. There also is some disagreement as to whether repairs made necessary by unusual events such as earthquakes, landslides, forest fires, windstorms, or severe traffic accidents should properly be classified as maintenance.

Taking all of these into consideration the definition which seems most nearly to fit is:

> Pavement maintenance is the routine work performed to keep a pavement, under normal conditions of traffic and normal forces of nature, as nearly as possible in its as-constructed condition.

1.04 WHY MAINTENANCE IS NECESSARY—All pavements require maintenance, the chief reason being that stresses producing minor defects are constantly working in all pavements. Such stresses may be caused by change in temperature or moisture content, by traffic, or by small movements in the underlying or adjacent earth. Cracks, holes, depressions, and other types of distress are the visible evidence of pavement wear. They are simply the end results of the process of wear which begins when construction ends. In urban areas, ditches dug through the pavement for water lines and other utilities are a major cause of pavement maintenance.

1.05 PREVENTIVE MAINTENANCE—*"A Stitch in Time . . ."*—The early detection and repair of minor defects is, without doubt, the most important work done by the maintenance crew. Cracks and other surface breaks, which in their first stages are almost unnoticeable, may develop into serious defects if not soon repaired. This may occur in a very few days on an underdesigned pavement under heavy traffic. For this reason, frequent close inspections of the pavement should be made by qualified men. Indeed, this measure is necessary toward the best use of maintenance money.

An inspection made from a moving vehicle, even one which creeps, is usually not close enough to detect areas where distress may begin. Often the cracks or other surface defects are so small that only a person on foot can spot them. There are other small signs, such as mud or water on the pavement or shoulder, which to an experienced observer may signal future trouble. It is best, then, to walk the pavement for close inspection;

or, when there are not enough men available for this purpose, to spot check selected stretches of roadway.

Upon detection of the warning signs, a detailed investigation, including trenching across the failed area if necessary, should be made to determine the kind of repair called for. If the pavement seems to be moving under traffic, deflection measurements should be carried out to determine the extent of the affected area (see *Benkelman Beam,* Chapter II).

All persons making pavement inspections on foot should take proper safety precautions. They should wear easily-seen clothes. They should be protected by adequate warning signs and devices, or followed by a car or truck displaying warning devices. Safety flags, vests, and caps of bright color are very effective.

1.06 DRAINAGE MAINTENANCE—A form of preventive maintenance is seasonal inspection and cleaning of drainage systems. If drains are kept working properly some of the major causes of pavement damage are eliminated. Each inspection should include all surface drainage structures, ditches and channels to insure that they are working as designed. If any part of the system is clogged, it should be cleaned out immediately.

At least twice a year subsurface drains should be examined to make sure they are working as intended. The abnormal appearance of water on the pavement surface may indicate that subsurface drains are improperly located, incorrectly designed, or clogged.

All drain outlets should be well marked on the ground and on maintenance maps. If this is done they will not be overlooked on inspection trips.

Detailed information about pavement drainage is contained in *Drainage of Asphalt Pavement Structures,* Manual Series No. 15 (MS-15), The Asphalt Institute. Most of the information in this manual applies equally to portland cement concrete pavements.

1.07 MAKE REPAIRS PROMPTLY—Repairs should be made as quickly as possible after the need for them is discovered. This is particularly important when the defect makes driving hazardous.

Often, weather conditions make temporary repairs necessary to prevent further damage until more permanent repairs can be made. As examples, crack filling is most likely to be successful during periods of cool, dry weather; chuck (pot) hole patches adhere best when the pavement is warm and dry; and seal coats, or other surface treatments, require warm and dry weather for best results. Selecting the best time to make repairs, therefore, involves the careful balancing of several things and requires both experience and judgment.

1.08 PREVENTION OF DEFECT RECURRENCE—In all cases of pavement distress it is best to determine first the cause or causes of the difficulty. Then repairs can be made which will not only correct the damage but will also prevent or retard its happening again. Time and money spent for such repairs are well spent because the same repairs will not have to be made over and over.

1.09 STREET MAINTENANCE—Street and urban roads can develop all of the defects discussed in Chapters II and III. However, some of these defects are much more of a problem in streets than in any other class of pavement structure. Shoving and corrugating of asphalt pavement surfaces, for example, show up more often in urban areas. Limited speeds on steep grades and frequent traffic lights and stop signs at intersections multiply the need for braking and the result is shoving or corrugating of low stability pavement surfaces. A heater-planer has been used successfully in repairing these defects (see *Corrugations and Shoving,* Chapter II).

A problem almost exclusive to urban areas is that of utility cuts in the pavement. In most cases these cuts are made by or for utility companies. And, although repairs are controlled by municipal regulations, all too often the backfilled trenches settle, requiring maintenance by the street department. Settlement can be minimized by selecting a well-graded granular backfill and compacting it, at the proper moisture content, with tampers or vibrating compactors. Compacting trench backfill by flooding or puddling with water is not a good procedure. For this to work at all, the in-place material surrounding the excavation must be more porous than the backfill material. And the backfill material must be granular and quite porous itself.

Utility Cuts, Chapter II, describes a procedure for repairing these settled patches in asphalt pavements. The same procedure is used for portland cement concrete pavements. When Full-Depth asphalt concrete is used for the repair the patch can be completed and opened quickly to traffic. Sometimes winter conditions or other considerations make temporary repairs necessary. But there are many utility cuts that can be permanently repaired the first time.

Often, in growing urban areas, streets become scarred from many cuts and patches for utility connections; or they are weathered and need sealing; or they become slippery from polished aggregate or bleeding asphalt. Many cities have found that a thin hot-mix overlay or a surface treatment is the most economical and effective treatment for these conditions.

Traffic control usually is more of a problem in urban areas than in rural areas. Street maintenance, then, must be done as quickly and as efficiently as possible with the least interference to, and from, traffic. Each city has its own special problems connected with traffic control and must solve them by its own method. The common goals of all, however, are to minimize disruption of traffic flow while providing maximum safety for the public and the maintenance crew.

1.10 THE IMPORTANCE OF SKILLED MAINTENANCE PERSONNEL—Maintenance work requires proper supervision, skilled workmen, and good workmanship. Unless all three are employed, it is likely that some repair work will be poorly done and may have to be repeated. Since most pavement repairs involve the use of asphalt, a thorough knowledge of this material is essential for maintenance men. This is especially true for supervisors and inspectors. Successful pavement maintenance requires a knowledge of which asphalts are available and how to use them (see Chapter IV). Although the basic skills needed for pavement maintenance can be acquired only through experience gained in the actual work, a close study of the literature published by The Asphalt Institute will be found most useful. The following publications are recommended for those engaged in maintenance work:

1. *Asphalt as a Material,* Information Series No. 93 (IS-93).
2. *Specifications for Asphalt Cements and Liquid Asphalts,* Specification Series No. 2 (SS-2).
3. *The Asphalt Handbook,* Manual Series No. 4 (MS-4).
4. *Asphalt Pavements for Airports,* Manual Series No. 11 (MS-11).
5. *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13).
6. *Asphalt Mixed-in-Place (Road-Mix) Manual,* Manual Series No. 14 (MS-14).
7. *Drainage of Asphalt Pavement Structures,* Manual Series No. 15 (MS-15).

1.11 THE IMPORTANCE OF WEATHER—Preferably, patching or resurfacing work should be done during warm (50°F and above) and dry weather. When hot or warm mixtures are placed on cold pavements, they may cool so fast that adequate compaction is difficult. This cooling effect is emphasized if the mixture is placed in thin layers. Moreover, asphalt and asphalt mixtures usually do not bond well to damp surfaces.

This does not mean that repairs cannot be made during cold or damp weather. Rather, they require much greater care when made during such periods. They also have much less chance of being satisfactory. It is better, however, when the safety and comfort of the traveling public are concerned, to make the repairs even though they may be only temporary. Also, a delay in repairs may allow small surface breaks to progress into major failures.

Mixtures containing liquid asphalts are slow in curing out when the humidity is high. This is because the air, which already contains a large amount of water vapor, does not readily allow solvent evaporation. Low temperatures also slow up solvent evaporation.

Seal coats and other surface treatments can be affected by moisture during the first few hours after their placement. Rain and/or fast traffic during this critical period will often result in the loss of most of the cover aggregate.

A phone call to the weather bureau may help in scheduling maintenance work during uncertain weather.

1.12 SAFETY—An important contribution to high-quality maintenance is an active safety program. For the maintenance man, safety measures reduce fear of injury, allowing him greater freedom of mind in performing his task. This results in his doing a better job.

For the safety of the workers, the motorist must be warned about what is going on ahead and what he must do as he passes through the work area. Signs and warning devices should be placed far enough ahead for him to grasp their meaning. Yet they should not be so far ahead that they lose their meaning. A sign indicating the end of the work area also is desirable. The use of flagmen near the work is necessary when sight distance is restricted or dangerous driving conditions exist.

The kind of safety equipment to be used by the maintenance men depends upon the type of work they are doing. Examples: If they are subsealing a portland cement concrete slab they should wear clothing and safety gear that leave no skin exposed, obviating injury in the event of hot asphalt blowing back from the hole. If they are merely sweeping a dirty pavement with a power broom, a dust mask and goggles may be all the extra equipment necessary. As appropriate, members of the maintenance crew should be furnished with hard hats, goggles, asbestos gloves, and any other safety apparel that will reduce the possibility of accidents.

Chapter II

MAINTENANCE OF ASPHALT PAVEMENTS

2.01 TYPES OF ASPHALT PAVEMENT—Asphalt pavement maintenance as discussed in this chapter applies to all asphalt pavement structures from Full-Depth asphalt to surface treatments (see *Definitions,* Chapter I). It applies to the traveled way and shoulders of roads, streets, runways and taxiways; to parking lots and aprons; and to other areas such as driveways. Asphalt overlays on portland cement concrete, brick, or other materials are also included.

This chapter covers the most common types of defects and failures in asphalt pavements, their usual causes, and suggested methods of repair. This does not imply, however, that the subject is completely covered. There may be unusual defects that do not fall into any of the following categories. There also are many good methods of repair that are not described here.

2.02 MOISTURE AND GRANULAR BASES—At the present time many asphalt pavements consist of an asphalt surface over a granular base. The base materials range from gravel and pit-run products to crushed and processed rock. These bases serve well as long as they are properly drained. But if they become saturated with water they lose strength rapidly under the weight and action of traffic.

Saturation of granular bases is the cause of many maintenance problems. Among them are asphalt-surfaced pavements on granular bases that become soft and crack in the familiar alligator or chicken-wire pattern. These are problems that won't go away by filling cracks or placing skin patches. The cause of the distress should be eliminated.

Many high-type pavements with granular bases are designed with drainage systems to prevent saturation by ground or surface water. But there are many thousands of miles of sand-clay-gravel roads, now surfaced with asphalt, that become saturated and give trouble. Usually these roads have a high percentage of plastic fine material in them as binder, needed to hold the materials in place when the surface was open. As sand-clay-gravel roads they became saturated when it rained but dried out rapidly because moisture was free to evaporate. With the addition of the impervious asphalt pavement, this evaporation through the surface is blocked. The result is that water migrating into the base materials from the shoulders and from the subgrade below cannot escape and the sand-clay-gravel loses strength as it becomes soaked. Cracking, heaving, and other forms of distress take place. Also, in its weakened condition the base, unable to support the traffic, deflects more than normal and cracking is intensified.

Therefore, when investigating surface failures which appear to be related to excessive deflection (see *Definitions,* Chapter I), the base should be checked for plastic fines or trapped water. If so, repair may call for digging out the broken area to sound material, improving drainage, and patching with asphalt patching mixture (Chapter IV).

2.03 BENKELMAN BEAM—The extent of areas of excessive deflection can be determined quite easily with a device called the Benkelman Beam. This device, pictured in Figure II-1, has a narrow beam that is slipped between the dual tires of the rear axle of a loaded truck. A foot on the end of the beam rests on the pavement between the tires. The truck moves ahead at creep speed and the total pavement rebound deflection is read by means of a dial gauge. (Rebound deflection is the amount of vertical rebound of a surface that occurs when a load is removed from the surface.)

Rebound deflection readings should be taken at locations sufficient to outline the whole area of excessive deflection before repairs are made. Areas of excessive deflection may be estimated by comparing deflection in the distressed area with the average deflection in areas that are performing well. *See* Appendix B for details of the deflection test procedure.

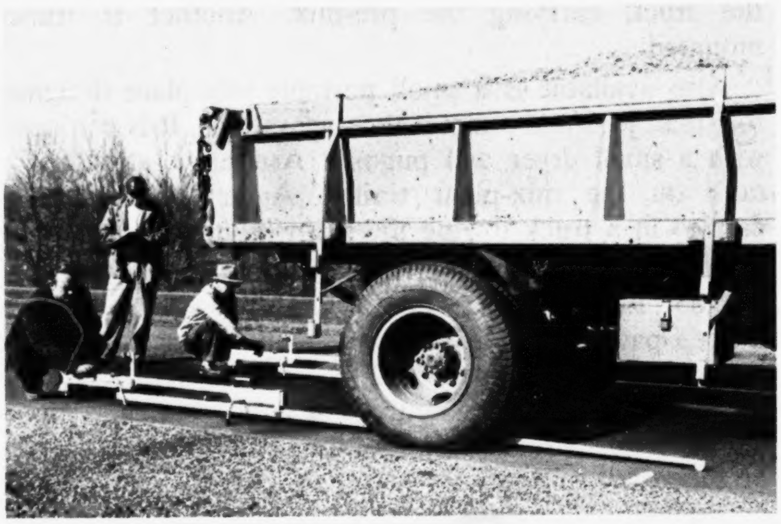

Figure II-1—Benkelman beam ***(Photo courtesy U.S. Bureau of Public Roads)***

2.04 PATCHING MIXTURES — Many patches bleed, become unstable, and are subject to pushing after placement. The cause usually is an excess of asphalt in the patching mixture. Patch instability can also be caused by not allowing the patch (when made with a *stockpiled* patching mixture) to cure before subjecting it to traffic.

For the best patching mixture a laboratory investigation should be made of the materials proposed for use (*see* Appendix A for specifications).

High-quality hot-mixed patching mixtures, although costing more than other patching materials, result in longer-lasting patches. The major cost of patching lies in placing the patch, not in the cost of the material. Therefore, the use of hot-mix materials for patches outlasting many times those made with other materials is a readily-apparent economy.

It is usually possible to get a hot asphalt mixture for patching, even in out-of-the-way areas. One method employs a mix-heater to heat stockpiled pre-mix prior to making the patch. There are several types of these heaters. One type can be suspended from the tailgate of the truck carrying the pre-mix. Another is trailer mounted.

Also available is a small portable mix-plant designed for small jobs and maintenance operations. It is equipped with a small dryer and pugmill. Asphalt is stored in a tank on the mix-plant trailer. Aggregate usually is carried in a truck towing the plant. Output at jobsite is 5-10 tons per hour of hot-mix material.

2.05 PRIME AND TACK COATS—If the base of a deep patch is made with untreated material it should be primed with 0.20 to 0.30 gallon per square yard of liquid asphalt. If spray equipment is not available, hand methods can be used to apply the prime. But care must be taken not to apply an excess of asphalt. The amount of asphalt material used to prime the base should be only enough to knit together the top particles.

The prepared edges of the surface surrounding the area being patched should be tack coated to ensure a bond between them and the patch material.

If the prime and tack coat are of asphalt emulsion, enough time should be allowed for the emulsion to "break" and most of the water to dry out before the patch-mix is placed. Similarly, a rapid curing or medium-curing asphalt should be given time to penetrate and cure before the patch mix is placed.

For a surface patch, a light tack coat is necessary. A slip plane may develop from either the absence of a tack coat or too heavy a tack coat. Application methods are similar to those used for a prime coat except that the quantities used are much smaller.

2.06 PLACING PATCHING MIXTURES—After the area to be patched has been properly prepared, including trimming of edges and applying the correct prime coat or tack coat, there remains only the placing and compacting of the mix.

Segregation should be prevented. Patching mixture should never be dumped from the truck into the patch area. It should be shoveled directly from the truck or from a board on to which it has been dumped. The shovels-full of mix should be placed against the edges first rather than piled in the center and raked to the edges.

It should never be necessary to pull material from the center of the patch to the edge in making the joint. If more material is needed at the edge it should be deposited there and the excess raked away. The quantity of material placed in the patch area should be sufficient to ensure that, after compaction, the patch surface will not be below that of the adjacent pavement. However, if too much material is placed in the patch area a hump will result. A stringline and/or a straightedge, used properly, can be a great help in producing a smooth riding surface. (*See* Figure II-2, Placing Patching Mixture.)

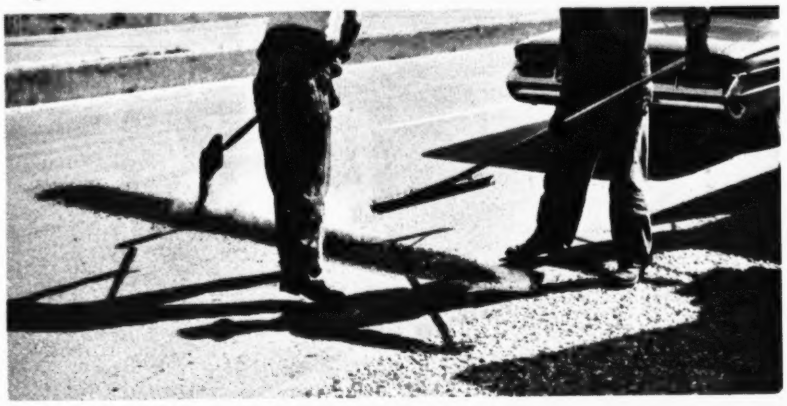

Figure II-2—Placing patching mixture

2.07 COMPACTING PATCHING MIXTURES—In compacting the patch, the first pass and return of the roller, vibratory compactor, or maintenance truck wheels (if these are used) should overlap not more than 6 inches on to the patch material at one edge. This should then be repeated on the opposite side to compact the material into the edge joints. Compaction should then proceed from the low side to the high side, with each pass and return lapping an additional few inches on to the patch. When proper equipment and procedures are used the surface of the patch should be at the same grade as the surrounding pavement. If hand tamping or other light compaction methods are used, however, the surface of the completed patch should be slightly higher than the pavement. Traffic will compress the patch further. (Figure II-3, Compacting Patching Mixture.)

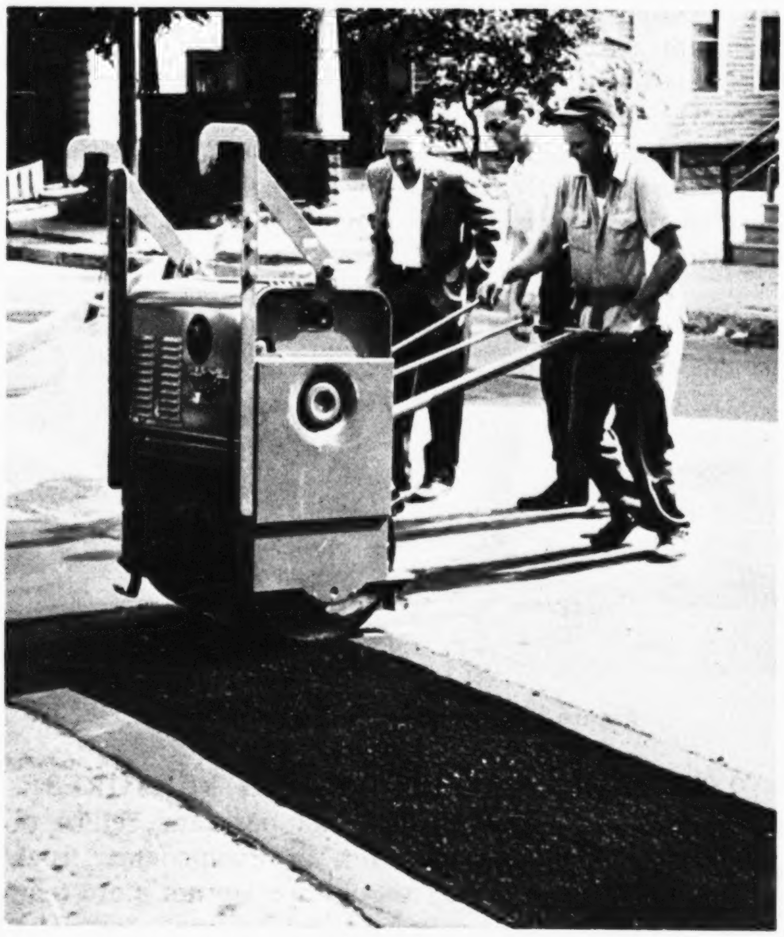

Figure II-3—Compacting patching mixture

A. Cracking

2.08 GENERAL—Cracking takes many forms. Simple crack filling may be the right treatment in some cases. In others, complete removal of the affected area and the installation of drainage may be necessary before effective repairs can be carried out. To make proper repairs, then, the necessary first step is to determine the cause of cracking.

The repair techniques for the correction of various forms of cracking discussed in this section are not necessarily the only correct ways to do the job. But they are proven ways that should result in neat, long-lasting repairs.

2.09 ALLIGATOR CRACKS—These are interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken-wire, Figure II-4.

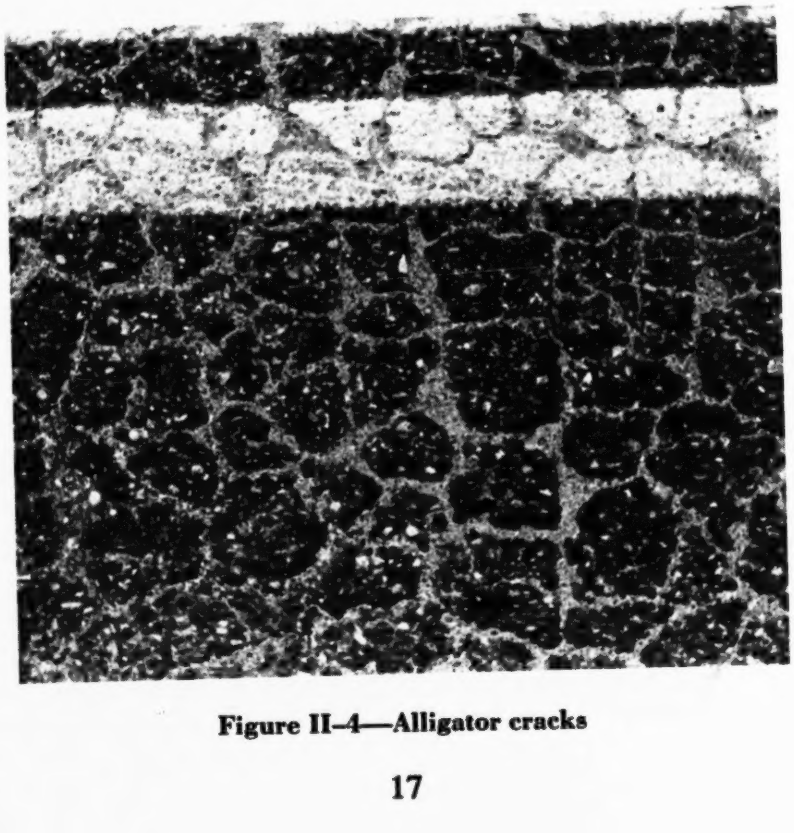

Figure II-4—Alligator cracks

(1) *Cause*—In most cases, alligator cracking is caused by excessive deflection of the surface over unstable subgrade or lower courses of the pavement. The unstable support usually is the result of saturated granular bases or subgrade. The affected areas in most cases are not large. Sometimes, however, they will cover entire sections of a pavement. When this happens, it probably is due to repeated loads that exceed the load-carrying capacity of the pavement.

(2) *Repair*—Since alligator cracking usually is the result of saturated bases or subgrades, correction should include removing the wet material and installing needed drainage. Asphalt plant-mixed material can then be used for the full depth for a strong patch. (This may be the least expensive repair because of the single operation with one material.) If the asphalt plant-mixed material is not available, new granular base material in layers not exceeding six inches each are compacted in. The granular base should then be primed and patched.

When necessary, temporary repairs can be made by applying skin patches or aggregate seal coats to the affected areas. In any event, repairs should be made promptly to avoid further damage to the pavement.

In the case of cracking from overloading, a properly-designed overlay will correct the condition. Refer to *A Short, Practical Guide to the Design of Asphalt Overlays,* Information Series No. 139 (IS-139), The Asphalt Institute.

Deep Patch (Permanent Repair)

(a) Remove the surface and base as deep as necessary to reach firm support, extending at least a foot into good pavement outside the cracked area, Figure II-5. This may mean that some of the subgrade will also have to be removed. Make the cut square or rectangular with faces straight and vertical. One pair of faces should be at right angles to the direction of traffic. A pavement saw makes a fast and neat cut.

(b) If water is a cause of the failure, install drainage.

(c) Apply a tack coat to the vertical faces, Figure II-6.

(d) For best results, backfill the hole with a dense-graded hot asphalt plant-mix. Figure II-7. Spread carefully to prevent segregation of the mixture, Figure II-8.

If the asphalt mixture is not available, make the backfill with a good granular base material. Part of the surface and upper base material removed from the hole, broken into small pieces and mixed thoroughly, can be placed in the bottom of the hole.

(e) Compact in layers if the hole is more than 6 inches deep. Compact each layer thoroughly, Figure II-9. Compaction should be done with equipment most suited for the size of the job. A vibratory plate compactor is excellent for small patches. A roller may be more practical for large areas.

(f) Full-Depth asphalt mix placed directly on the subgrade needs no prime.

(g) If granular base is used it should be primed. The repair is then completed by placing hot plant-mixed asphalt surfacing material, and compacting to the same grade as the surrounding pavement. If hot-mixed surfacing is not available, plant-mixed material using liquid asphalt can be used.

(h) Use a straightedge or a stringline to check the riding quality and the alignment of the patch, Figure II-10.

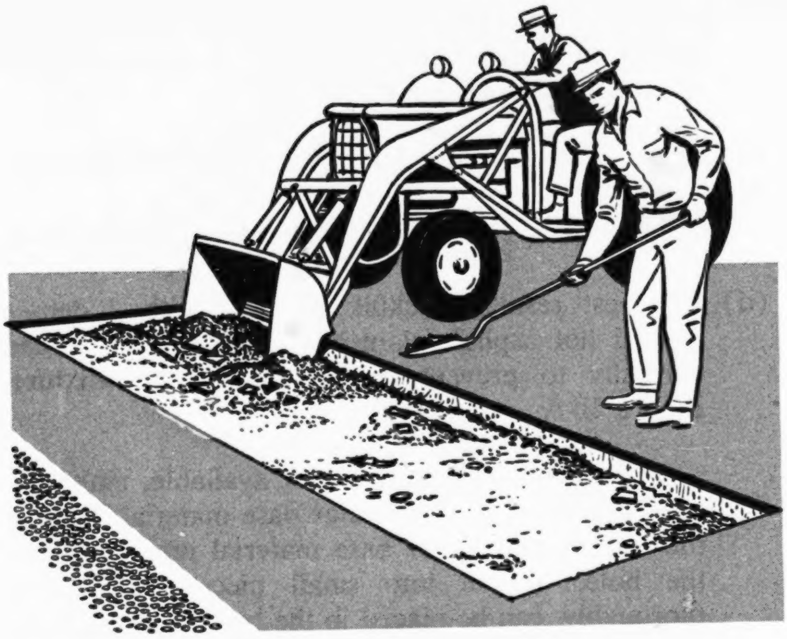

Figure II–5—Removing surface and base

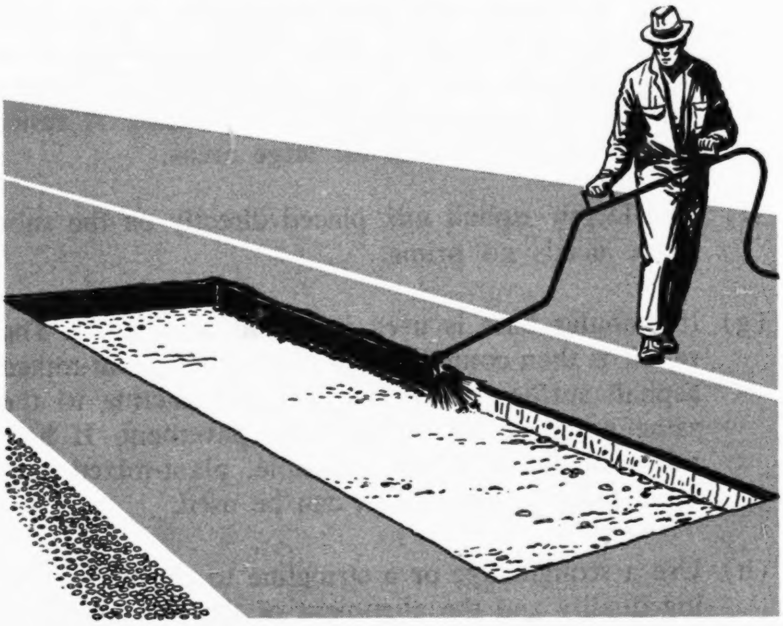

Figure II–6—Applying tack coat to vertical surfaces

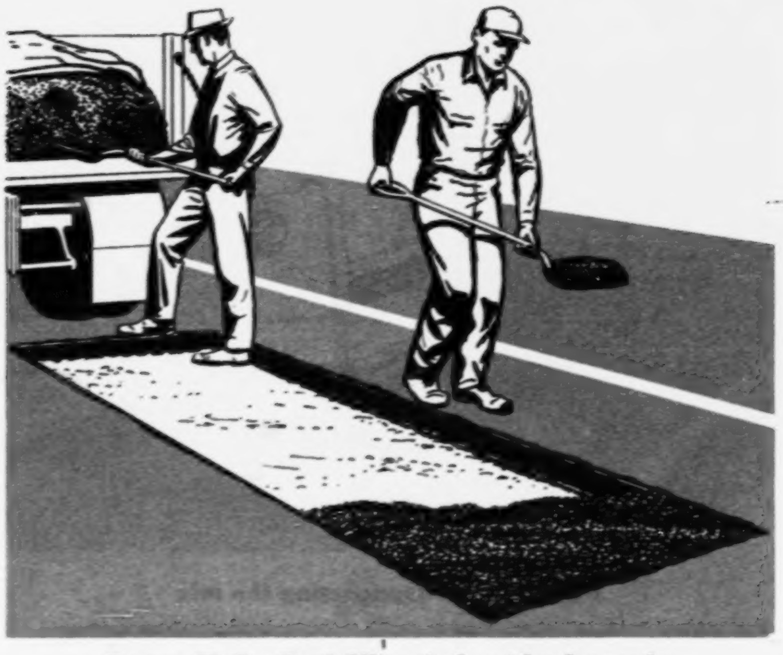

Figure II–7—Backfilling hole with plant-mix

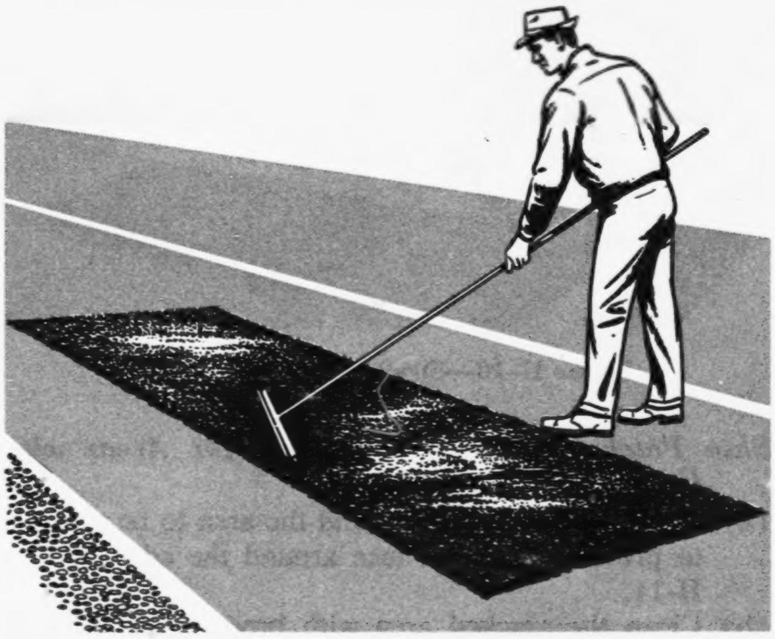

Figure II–8—Spreading the mix

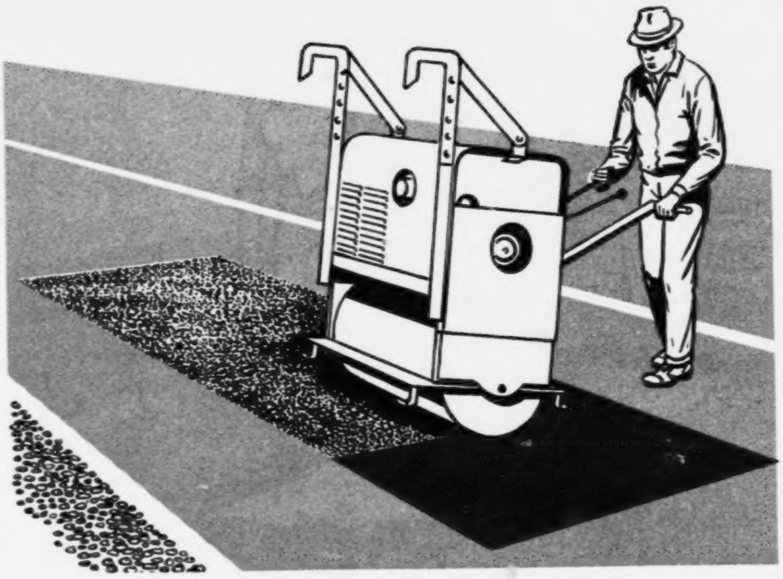

Figure II-9—Compacting the mix

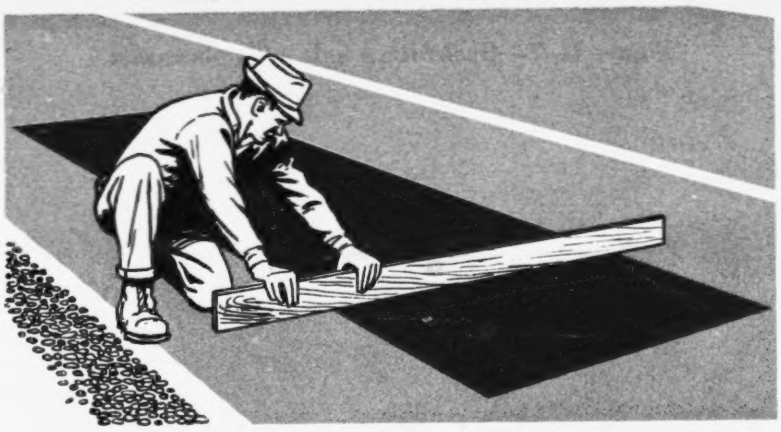

Figure II-10—Straightedging the patch

Skin Patch (Temporary Repair) for Areas with Cracks Wider than 1/8 inch

(a) Cut a shallow trench around the area to be patched to provide a vertical face around the edge, Figure II-11.

(b) Clean the cracked area with brooms and, if necessary, compressed air.

(c) Broom plant-mixed fine-graded asphalt material into cracks, Figure II-12.

(d) Compact with a vibratory plate compactor or roller, Figure II-13, or roll with rear wheel of a loaded truck.

(e) Apply a tack coat, Figure II-14.

(f) Place a skin patch with hot plant-mixed asphalt material, Figure II-15. If this material is not available, use plant mix with liquid asphalt. Feather the edges carefully, removing coarse particles with lute and rake before compaction.

(g) Compact the patch with a vibratory plate compactor or roller, Figure II-16. If neither is available, rolling may be done with the wheels of the truck that carries the mix.

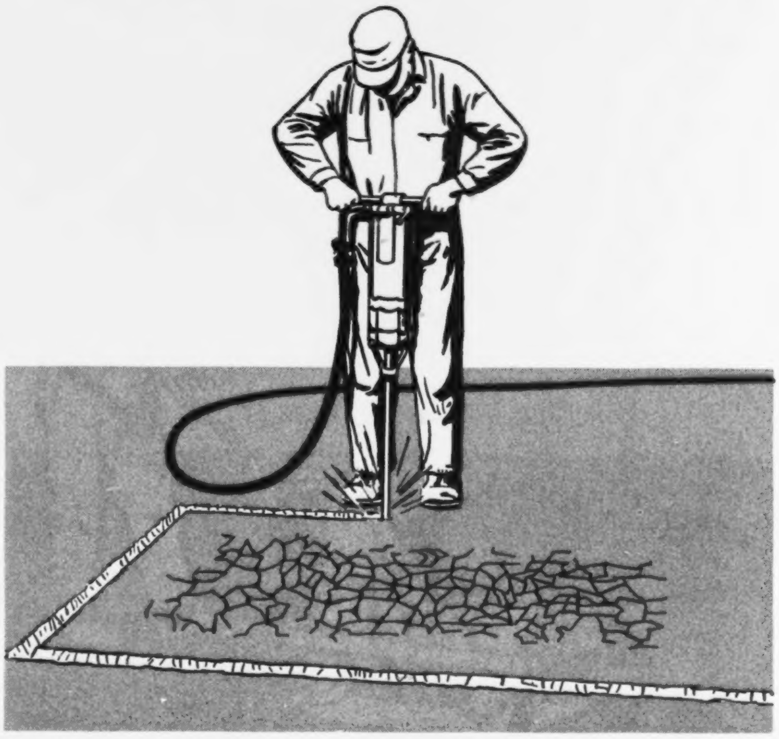

Figure II-11—Cutting vertical face around cracked area

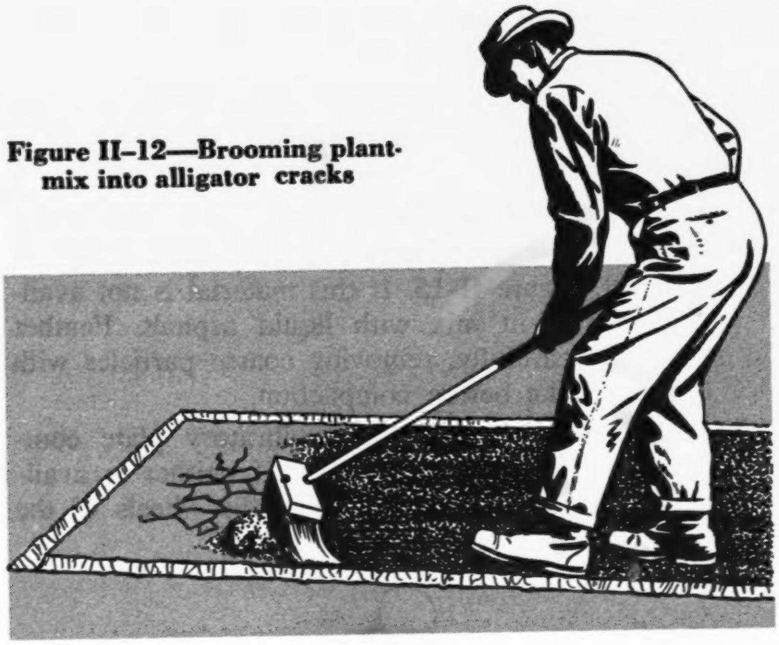

Figure II-12—Brooming plant-mix into alligator cracks

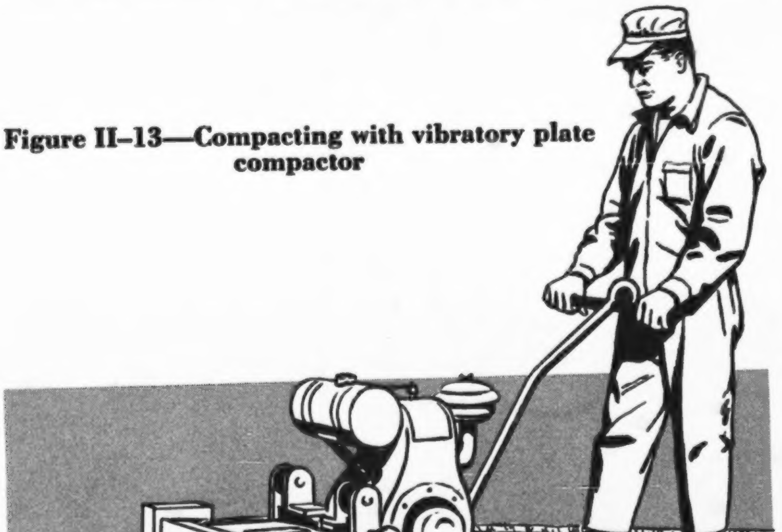

Figure II-13—Compacting with vibratory plate compactor

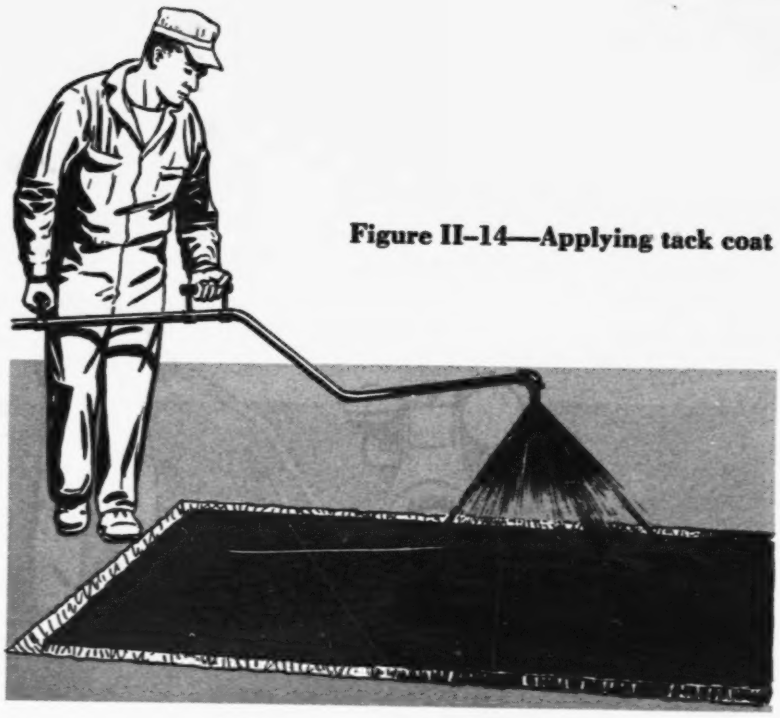

Figure II-14—Applying tack coat

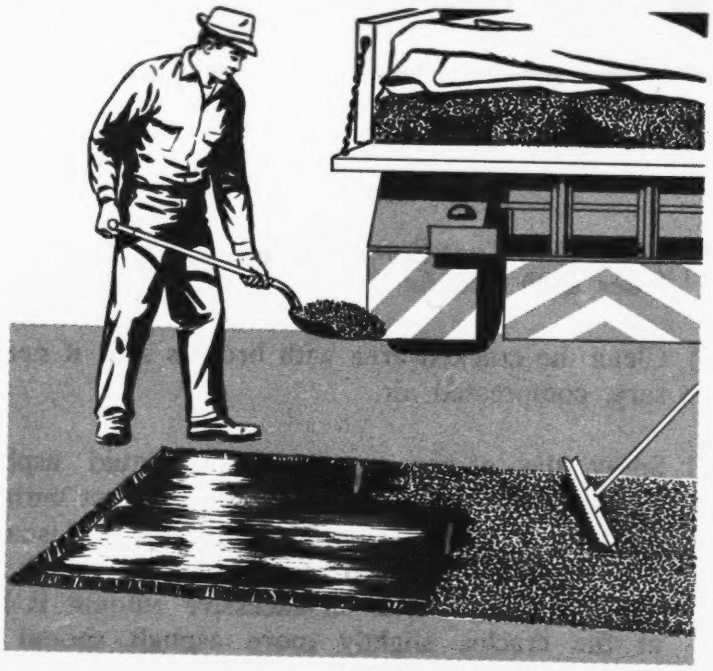

Figure II-15—Placing skin patch of hot plant-mix

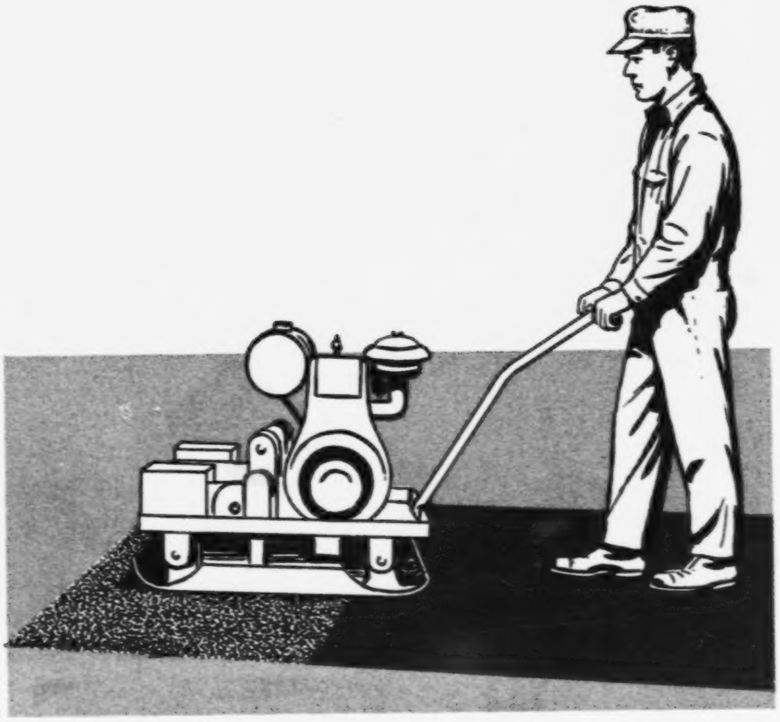

Figure II-16—Compacting with vibratory plate compactor

Aggregate Seal Coat Patch (Temporary Repair) for Areas with Cracks Narrower than 1/8 inch

(a) Clean the cracked area with brooms and, if necessary, compressed air.

(b) Spray the necessary amount of liquid asphalt (either emulsion rapid curing, or medium curing) on to the cleaned area, Figure II-17. Usually, 0.15 or 0.25 gallon per square yard is enough for the seal coat, but, if an excessive amount is lost in the cracks, slightly more asphalt should be applied.

(c) Apply the cover aggregate *immediately* after spraying the asphalt, Figure II-18. A good aggregate size for this type of patch is ¼ inch to No. 10 screenings.

(d) Roll the seal coat with rubber-tired equipment, Figure II-19. If a roller is not available the wheels of the truck carrying the cover aggregate can be used.

(e) If it is necessary to build up the patched area to the level of the surrounding pavement, a second seal coat can be applied.

(f) Allow to cure thoroughly before opening to traffic.

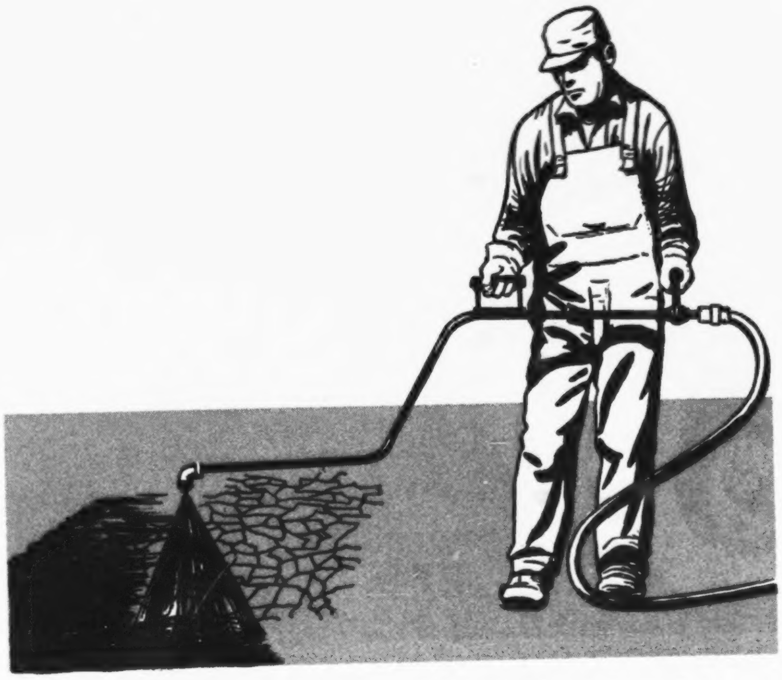

Figure II-17—Spraying asphalt on alligator cracks

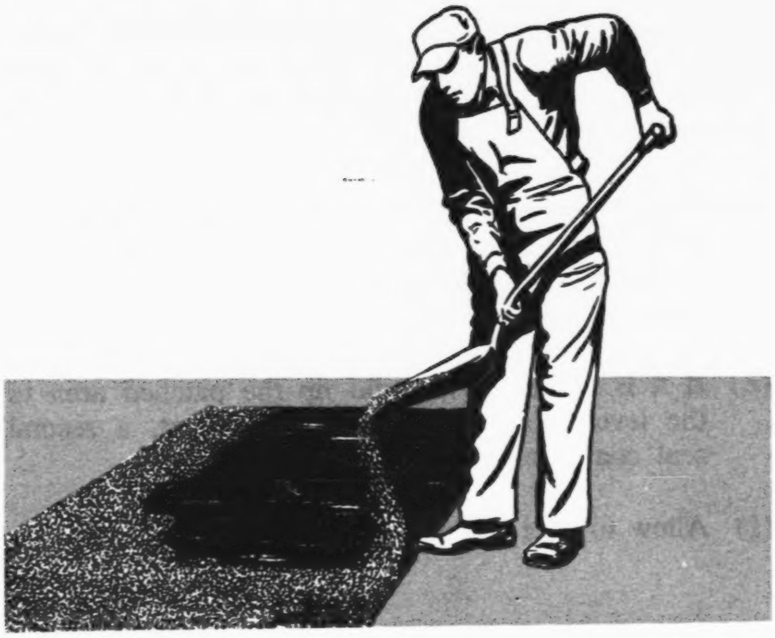

Figure II–18—Applying cover aggregate

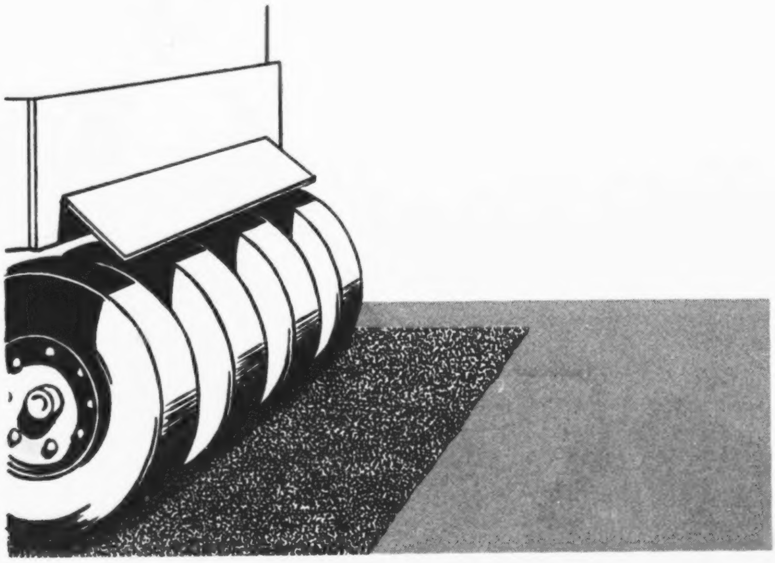

Figure II–19—Rolling seal coat with rubber-tired equipment

Slurry Seal Patch (Temporary Repair) for Areas Cracked from Overloading

(a) Clean the cracked area with brooms and, if necessary, compressed air.

(b) Apply an asphalt emulsion slurry seal according to Specification ST-3, *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13), The Asphalt Institute.

2.10 EDGE CRACKS—These are longitudinal cracks a foot or so from the edge of the pavement, with or without transverse cracks branching towards the shoulder, Figure II-20.

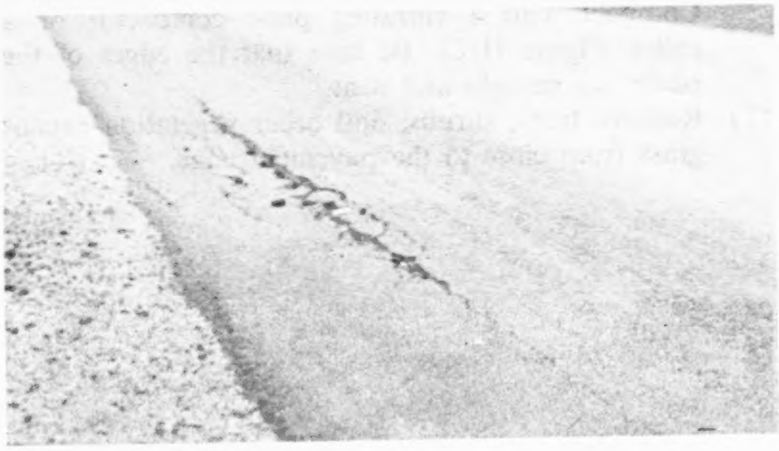

Figure II-20—Edge crack (*Photo courtesy Ohio Highway Department*)

(1) *Cause*—Usually, edge cracks are due to lack of lateral (shoulder) support. They may also be caused by settlement or yielding of the material underlying the cracked area; which in turn may be the result of poor drainage, frost heave, or shrinkage from drying out of the surrounding earth. In the last case trees, bushes or other heavy vegetation close to the pavement edge may be a cause.

(2) *Repair*—For temporary repair, fill as for reflection cracks. For more permanent repair, fill cracks with asphalt emulsion slurry or liquid asphalt mixed with sand. If the edge of the pavement has settled, bring up to grade with hot plant mix patching material.

(a) Improve drainage. Install underdrains, if necessary.
(b) Clean pavement and cracks with broom and compressed air.
(c) Fill cracks with emulsion slurry or liquid asphalt (SS-1, SS-1h, or SM-K) mixed with sand. Wipe with a rubber-edged squeegee.
(d) Apply a tack coat, Figure II-21.
(e) Bring settled edge up to grade by spreading hot asphalt plant-mixed material, Figure II-22. Check the smoothness with a straightedge or a stringline. Compact with a vibrating plate compactor or a roller, Figure II-23. Be sure that the edges of the patch are straight and neat.
(f) Remove trees, shrubs, and other vegetation except grass from close to the pavement edge.

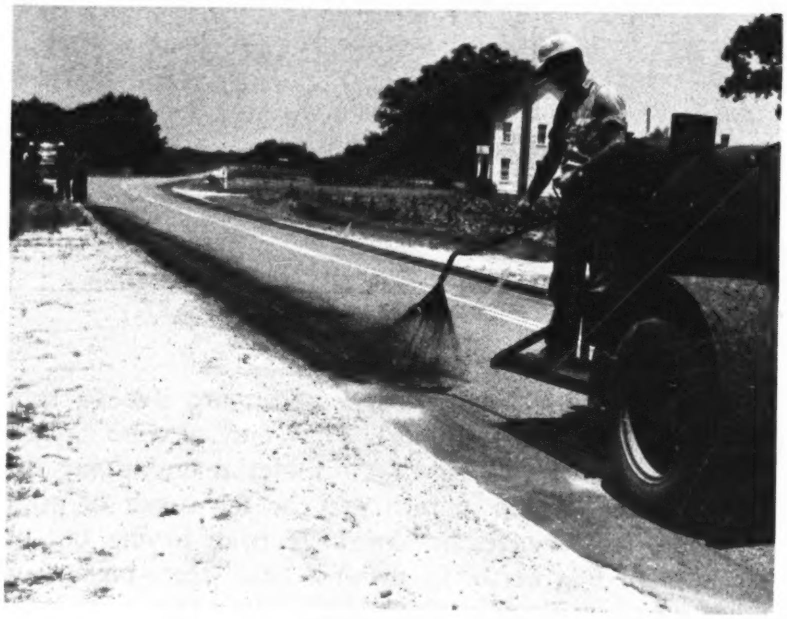

Figure II-21—Applying tack coat

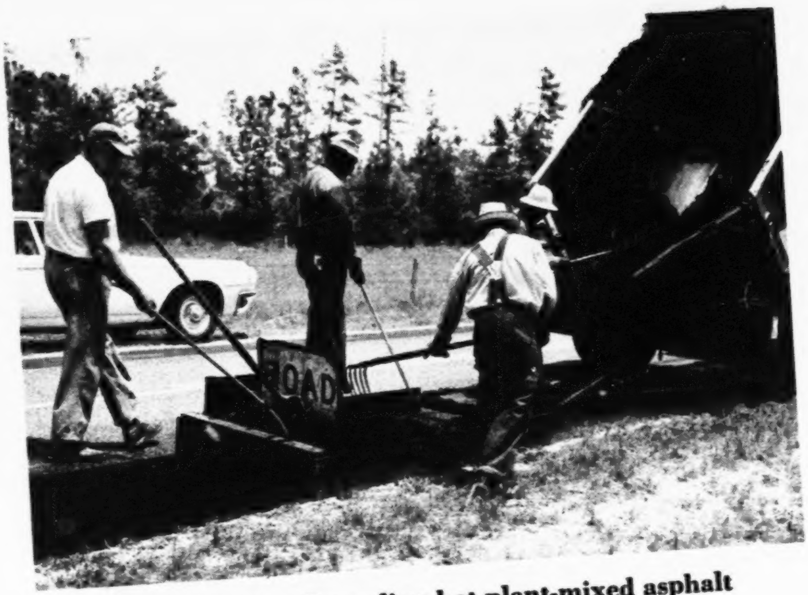

Figure II–22—Spreading hot plant-mixed asphalt material on settled edge

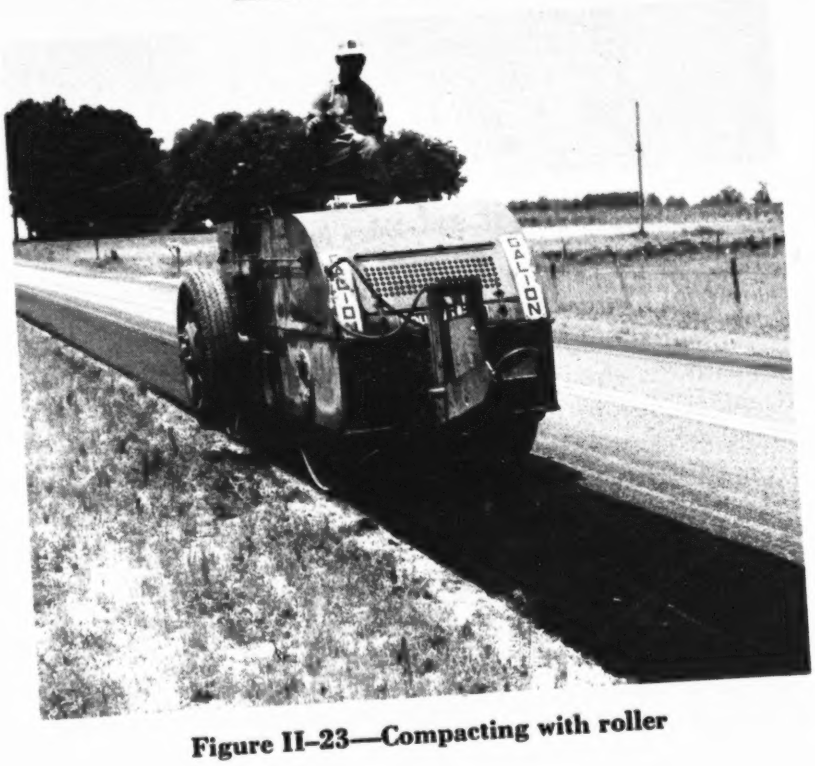

Figure II–23—Compacting with roller

2.11 EDGE JOINT CRACKS—An edge joint crack is really a seam. It is the separation of the joint between the pavement and the shoulder, Figure II-24. It is treated as a crack, however.

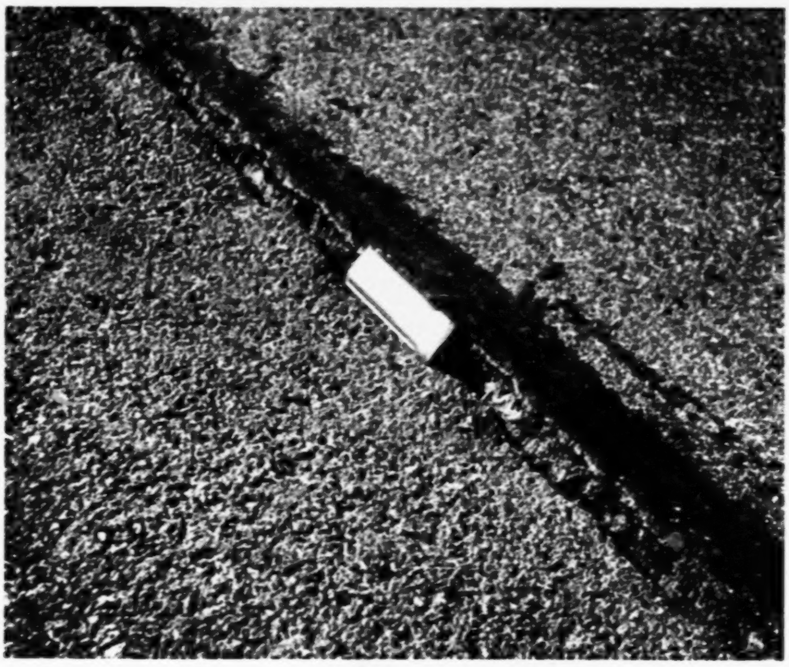

Figure II-24—Edge joint crack

(1) *Cause*—A common cause of "cracking" in a pavement-shoulder joint is alternate wetting and drying beneath the shoulder surface. This may result from poor drainage due to a shoulder higher than the main pavement, from a ridge of grass or joint-filling material, or from depressions in the pavement edge, all of which trap water and allow it to stand along and seep through the joint. Other causes are shoulder settlement, mix shrinkage, and trucks straddling the joint.

(2) *Repair*—If water is the cause, the first step is to improve the drainage by getting rid of the condition that traps water. Then repair the crack, see *Reflection Cracks* below.

2.12 LANE JOINT CRACKS—Lane joint cracks are are longitudinal separations along the seam between two paving lanes, Figure II-25.

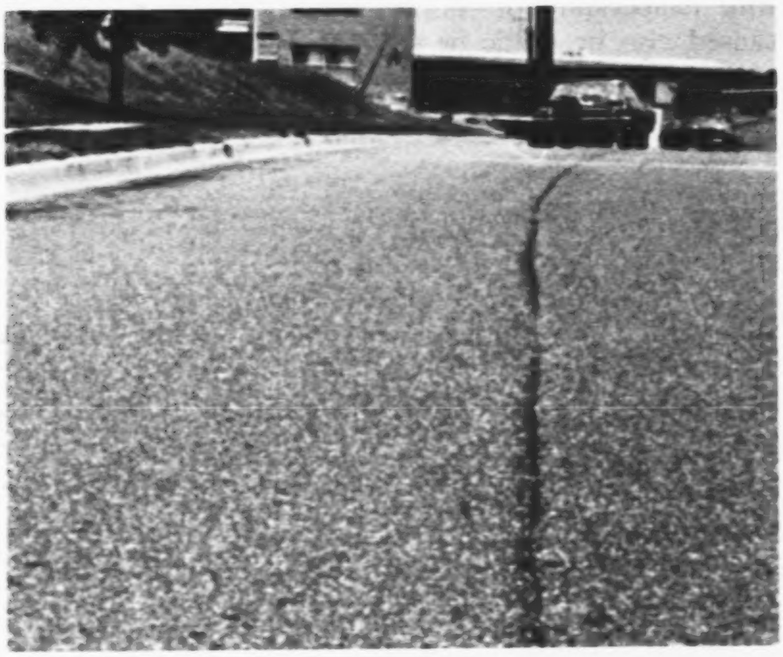

Figure II-25—Lane joint crack

(1) *Cause*—This type of crack usually is caused by a weak seam between adjoining spreads in the courses of the pavement.

(2) *Repair*—See *Reflection Cracks.*

2.13 REFLECTION CRACKS—These are cracks in asphalt overlays which reflect the crack pattern in the pavement structure underneath, Figure II-26. The pattern may be longitudinal, transverse, diagonal, or block. They occur most frequently in asphalt overlays on portland cement concrete and on cement-treated bases. They may also occur in asphalt overlays on asphalt pavements whenever cracks in the old pavement have not been properly repaired.

(1) *Cause*—Reflection cracks are caused by vertical or horizontal movements in the pavement beneath the overlay, brought on by expansion and contraction with temperature or moisture changes. They may be caused also by traffic or earth movements and by loss of moisture in subgrades with high clay contents.

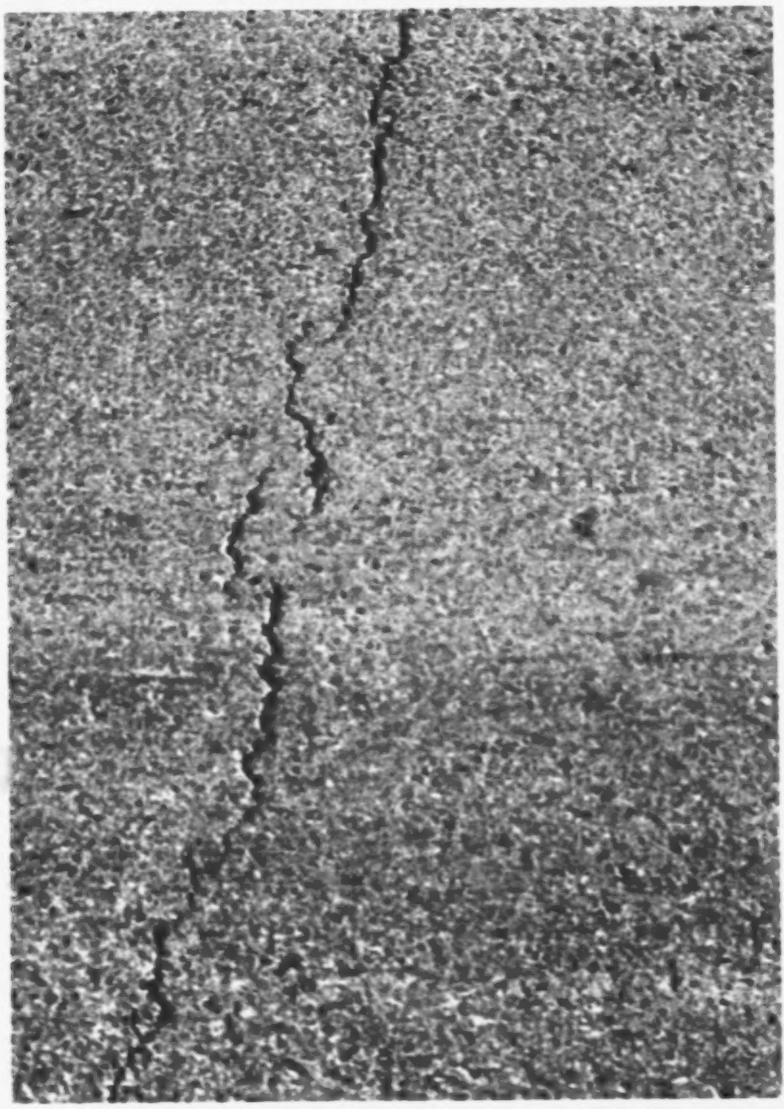

Figure II–26—Reflection crack

(2) *Repair*—Small cracks (less than ⅛ in. in width) are too small to seal effectively. Large cracks (⅛ in. and over in width) are to be filled with asphalt emulsion slurry or light grade of liquid asphalt mixed with fine sand. Also, special asphalt compounds or heavier bodied asphalt material may be used to fill large cracks.

(a) Clean out crack with stiff-bristled broom and compressed air, Figure II-27.

(b) Large crack. Using a hand squeegee and a broom, fill (do not overfill) with emulsion slurry or liquid asphalt (SS-1, SS-1h, or SM-K) mixed with sand. When cured, seal with liquid asphalt using a pouring pot and a hand squeegee, Figure II-28.

(c) Sprinkle surface of crack filler with dry sand to prevent pick-up by traffic, Figure II-29.

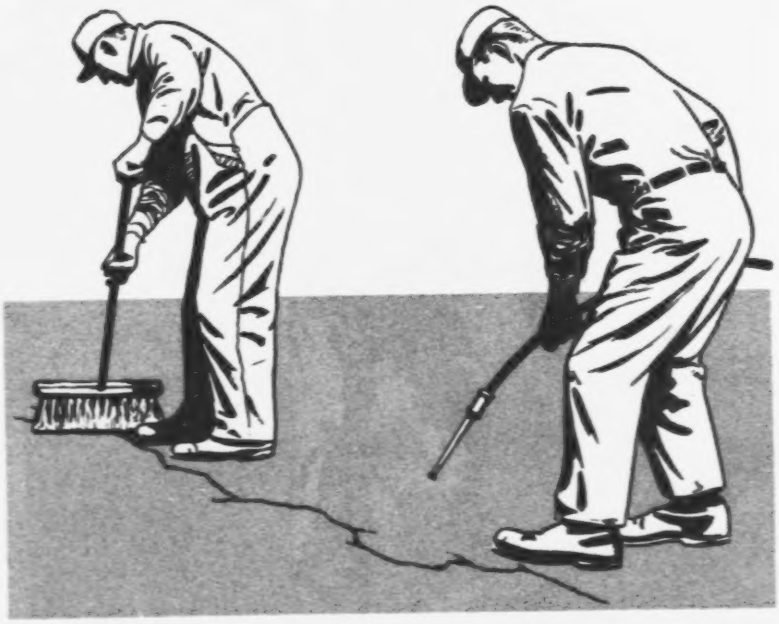

Figure II-27—Cleaning out crack with broom and air

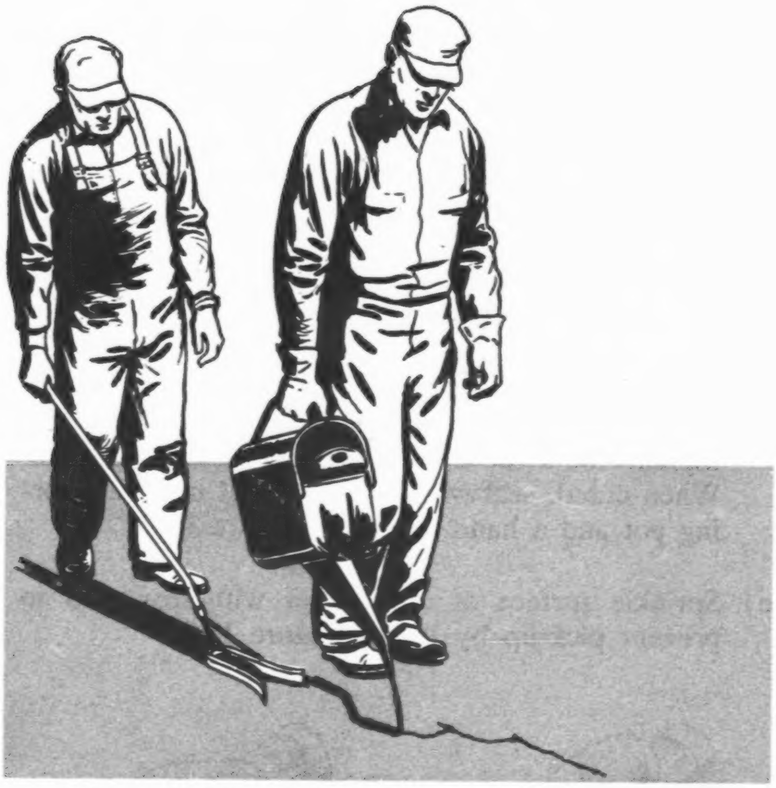

Figure II–28—Sealing with pouring pot and hand squeegee

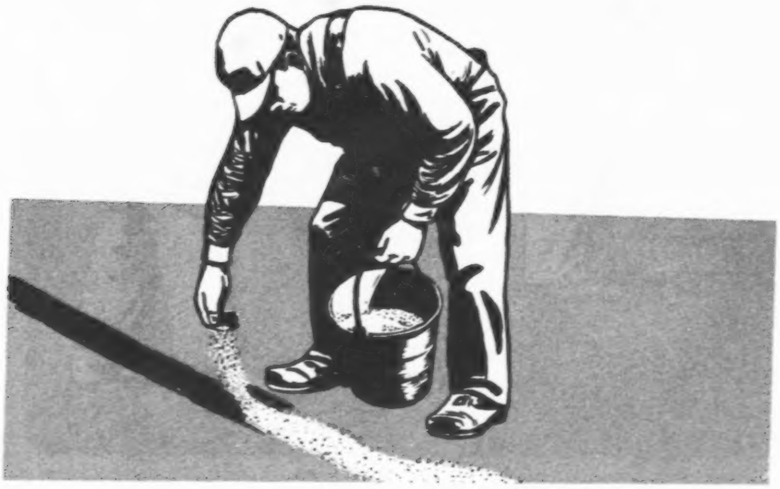

Figure II–29—Sprinkling surface with dry sand

2.14 SHRINKAGE CRACKS—Shrinkage cracks are interconnected cracks forming a series of large blocks, usually with sharp corners or angles, Figure II-30.

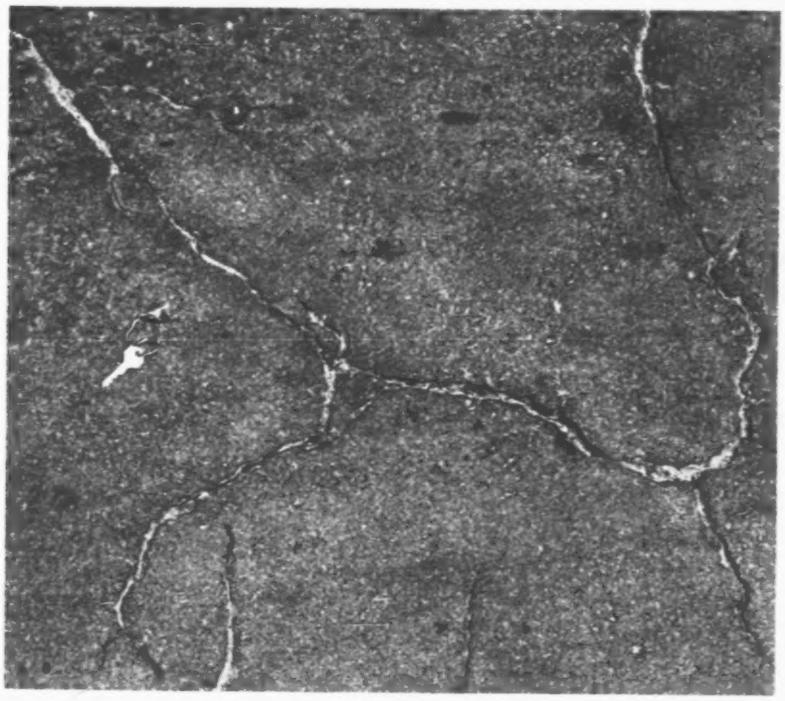

Figure II-30—Shrinkage cracks

(1) *Cause*—Often it is difficult to determine whether shrinkage cracks are caused by volume change in the asphalt mix or in the base or subgrade. Frequently, they are caused by volume change of fine aggregate asphalt mixes that have a high content of low penetration asphalt. Lack of traffic hastens shrinkage cracking in these pavements.

(2) *Repair*—Fill cracks with asphalt emulsion slurry followed by a surface treatment or a slurry seal over the entire surface. (Refer to The Asphalt Institute's Specification ST-1 or Specification ST-3, *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13.)

(a) Remove all loose matter from the cracks and pavement surface with brooms and compressed air, Figure II-31.
(b) Wet with water the surface of the pavement and all crack faces.
(c) When all surfaces are uniformly damp, with no free water, apply a tack coat of asphalt emulsion diluted with equal parts of water, Figure II-32.

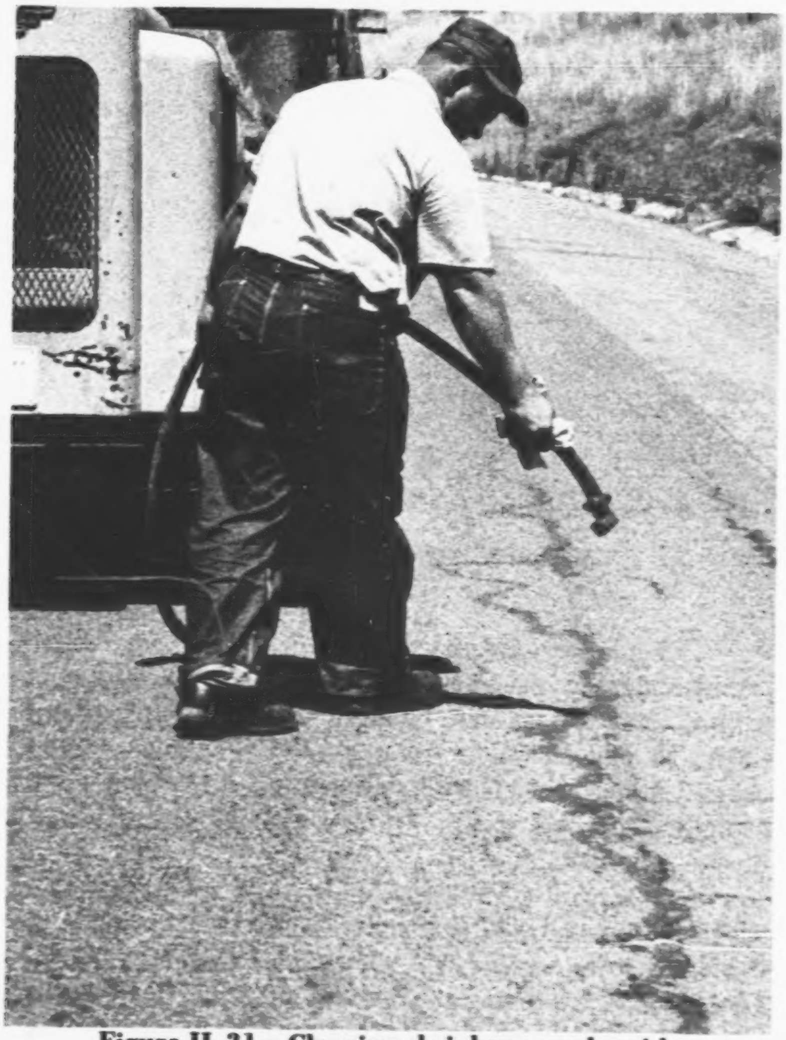

Figure II-31—Cleaning shrinkage cracks with compressed air

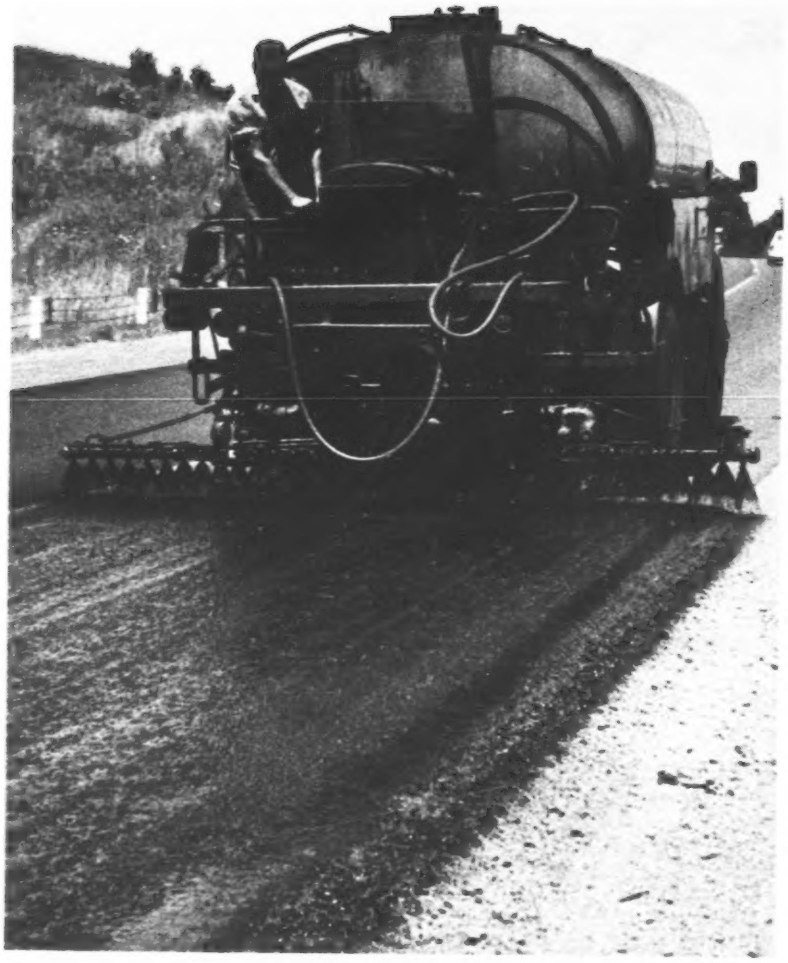

Figure II-32—Applying tack coat

(d) Prepare the asphalt emulsion slurry mixture.
(e) Pour slurry mixture into cracks and level with a hand squeegee, Figure II-33. (If cracks are numerous slurry-seal the whole surface.)
(f) When the slurry is cured until firm, surface-treat or slurry-seal the whole surface with equipment designed for the operation, Figure II-34.
(g) Allow to cure until firm enough to prevent pick-up by traffic.

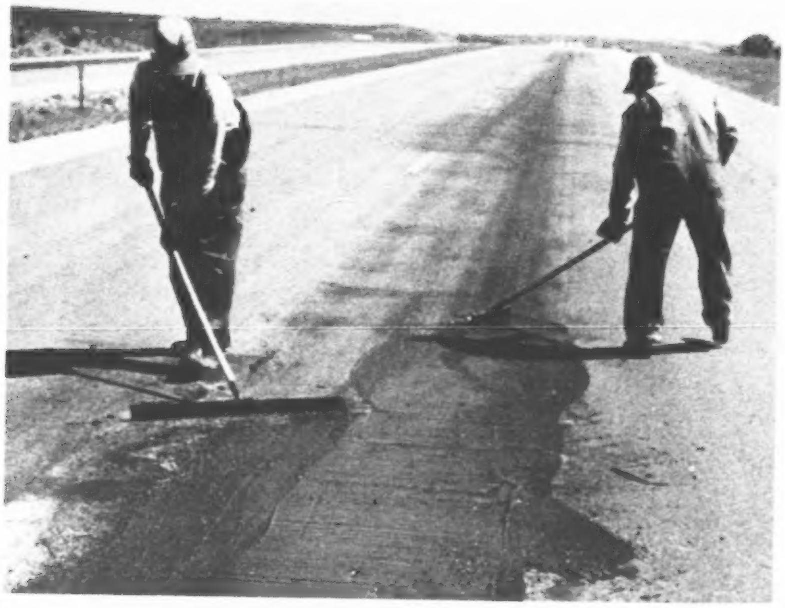

Figure II–33—Filling shrinkage cracks with slurry seal

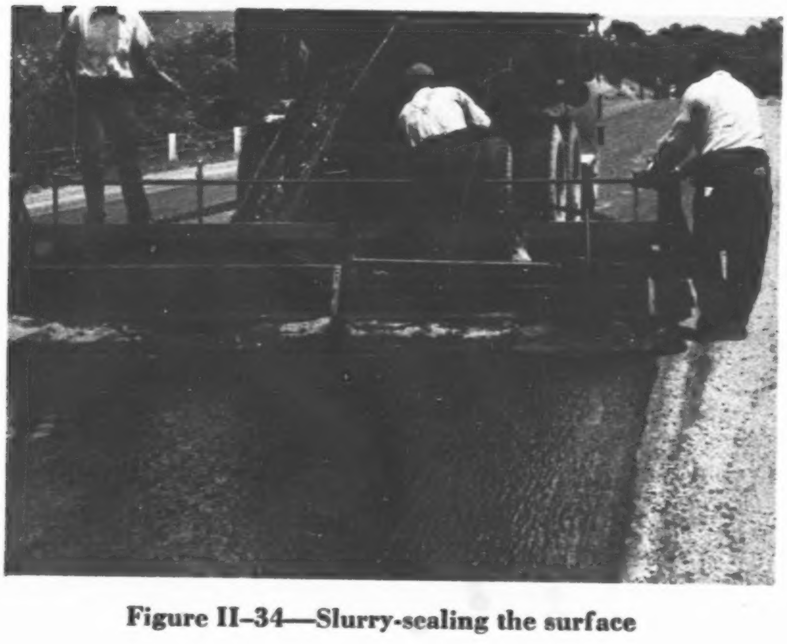

Figure II–34—Slurry-sealing the surface

2.15 SLIPPAGE CRACKS—These are sometimes crescent-shaped cracks that point in the direction of the thrust of wheels on the pavement surface, Figure II-35. This does not mean that they invariably point in the direction that traffic is going. For example, if brakes are applied on a vehicle going down a hill the thrust of the wheels is reversed. Slippage occurring in this circumstance will result in cracks pointing uphill.

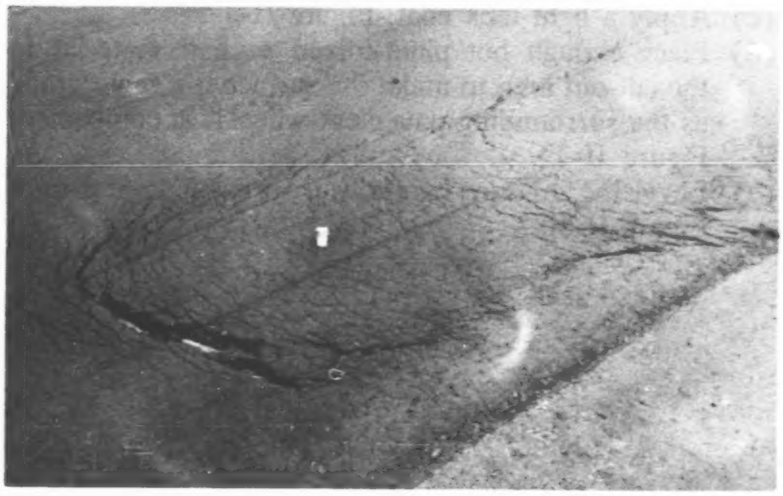

Figure II-35—Slippage cracks

(1) *Cause*—Slippage cracks are caused by the lack of a good bond between the surface layer and the course beneath. The lack of bond may be due to dust, oil, rubber, dirt, water, or other non-adhesive material between the two courses. Usually, such a lack of bond exists when no tack coat has been used. Slippage cracks may also be due to a mixture having a high sand content, and they can occur whether the sand is sharp or rounded. Sometimes slippage may develop under traffic because improper compaction during construction caused the bond layers to be broken.

(2) *Repair*—The only proper way to repair a slippage crack is to remove the surface layer from around the crack to the point where good bond between

the layers is found. Then patch the area with plant-mixed asphalt material.

(a) Remove the slipping area and at least one foot into the surrounding well bonded pavement. Make the cut faces straight and vertical. A power pavement saw makes a fast and neat cut, Figure II-36.

(b) Clean the surface of the exposed underlying layer with brooms and compressed air, Figure II-37.

(c) Apply a light tack coat, Figure II-38.

(d) Place enough hot plant-mixed asphalt material in the cut-out area to make the surface the same grade as the surrounding pavement when it is compacted, Figure II-39.

(e) Level the mixture carefully to prevent segregation, Figure II-40.

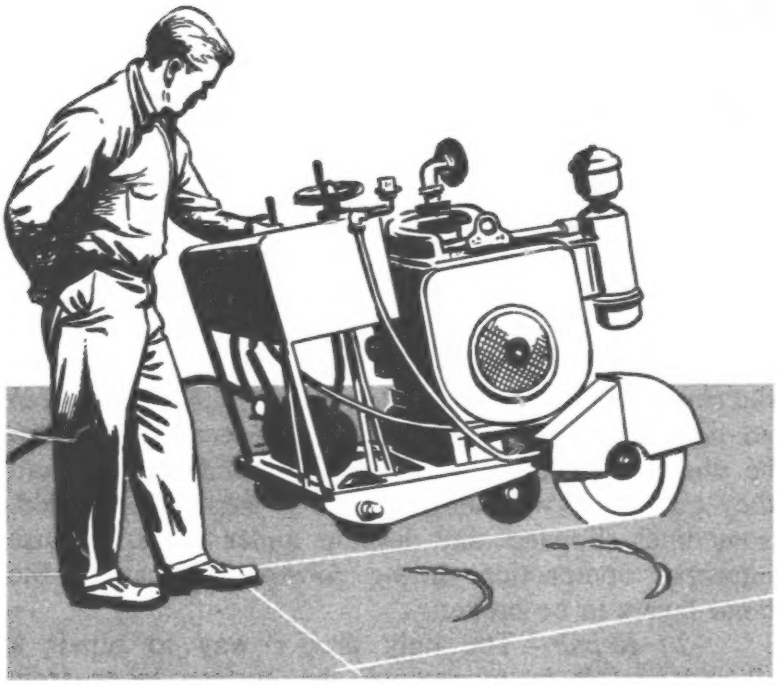

Figure II-36—Cutting with power saw

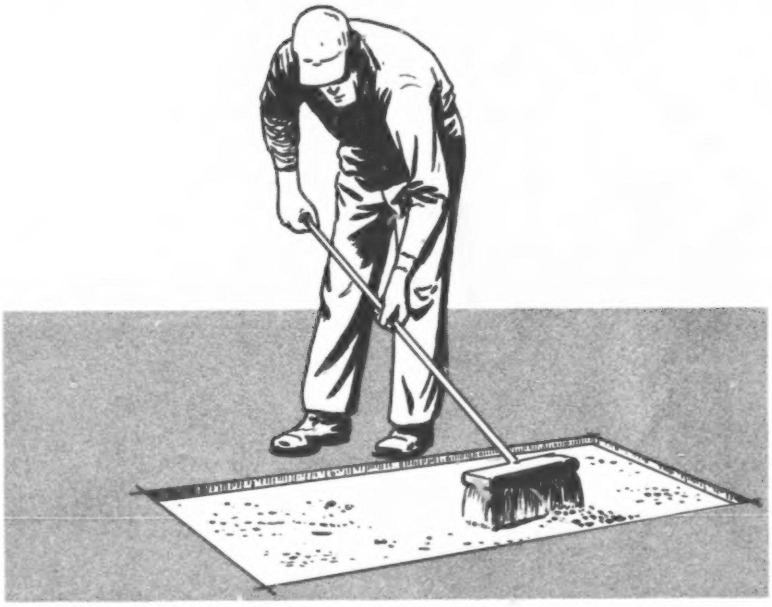

Figure II-37—Cleaning surface of exposed layer

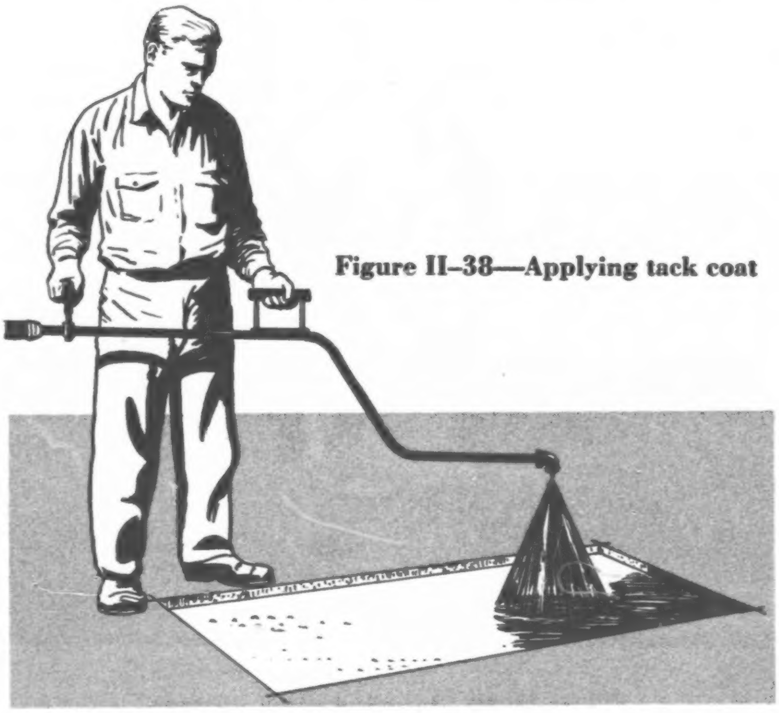

Figure II-38—Applying tack coat

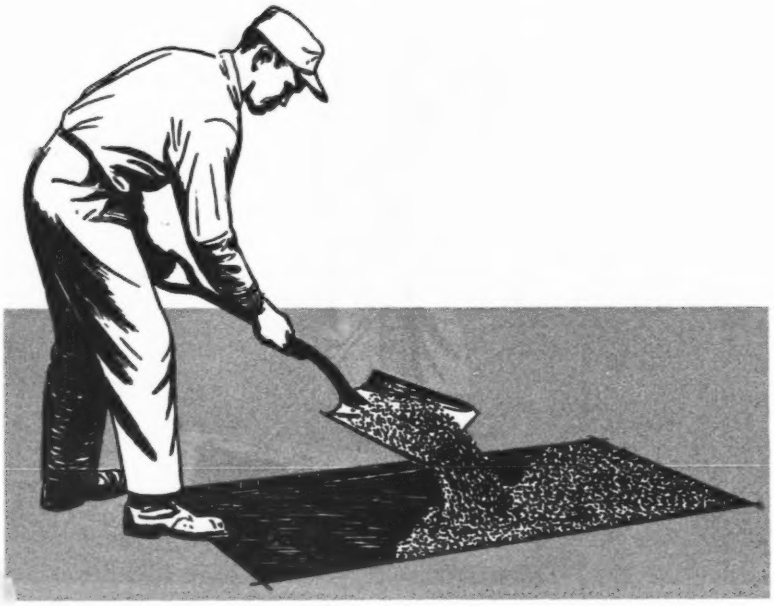

Figure II–39—Placing plant-mix in cut

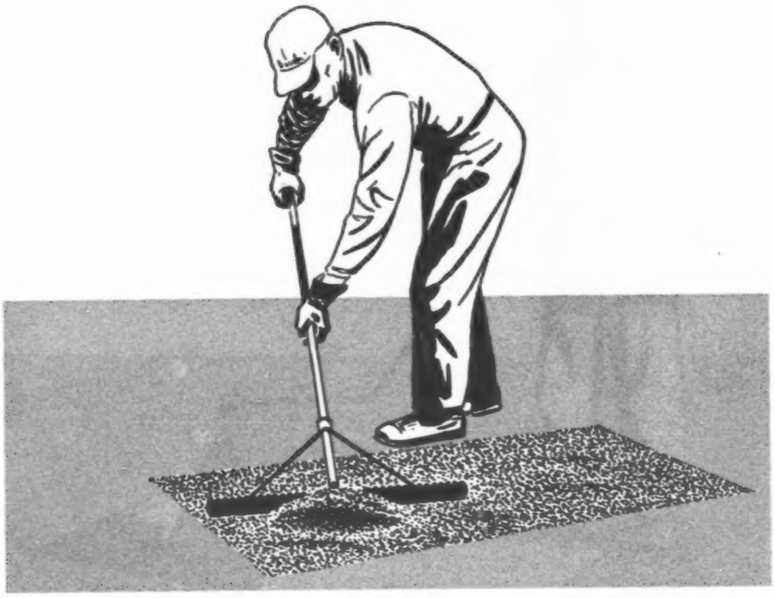

Figure II–40—Leveling patch mixture

(f) Check the riding quality of the patch with a straightedge or a stringline, Figure II-41.

(g) Compact thoroughly with a vibrating plate compactor or a steel-wheeled roller, Figure II-42.

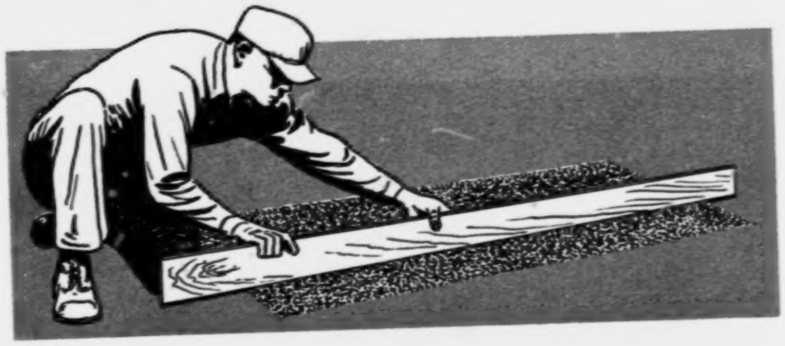

Figure II–41—Checking with straightedge

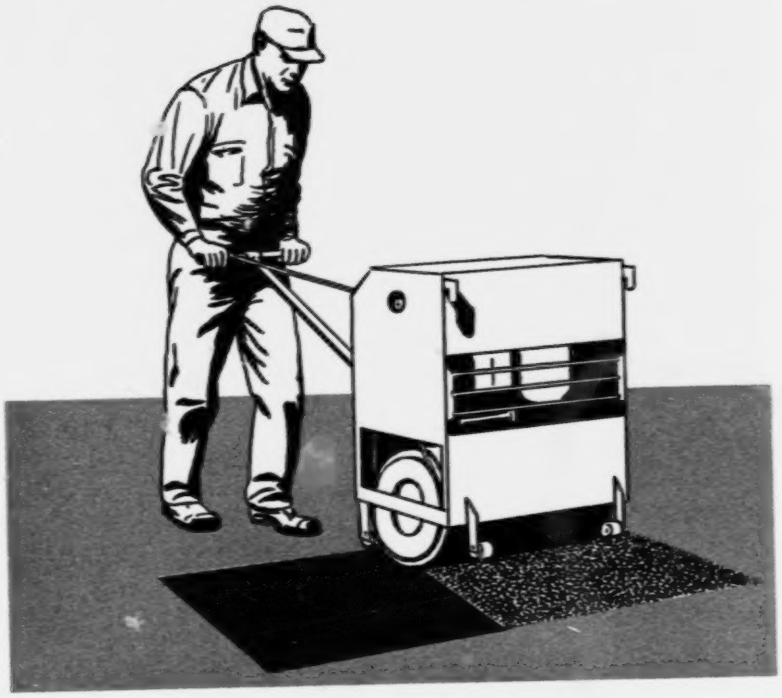

Figure II–42—Compacting with roller

2

2.16 WIDENING CRACKS—Widening cracks are longitudinal reflection cracks that show up in the asphalt overlay above the joint between the old and new sections of a pavement widening, Figure II-43.

(1) *Cause*—see *Reflection Cracks* (Article 2.13).

(2) *Repair*—see *Reflection Cracks* (Article 2.13).

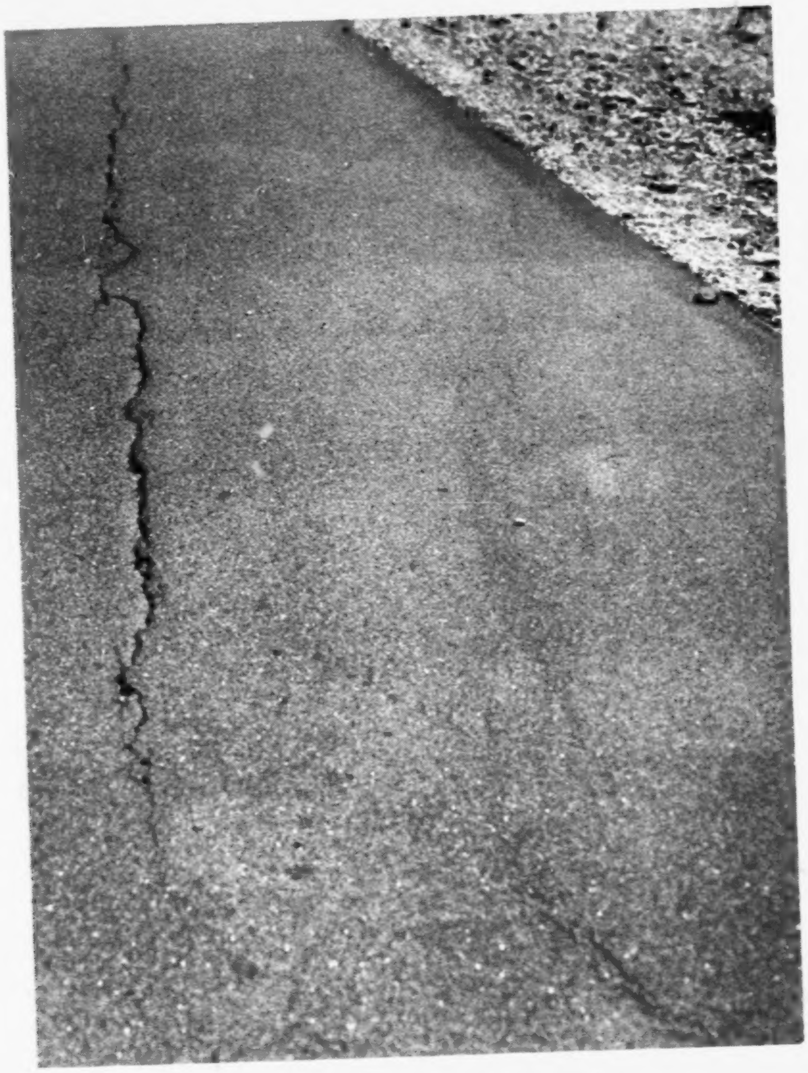

Figure II-43—Widening crack

B. Distortion

2.17 GENERAL—Pavement distortion is any change of the pavement surface from its original shape. It usually is caused by such things as too little compaction of the pavement courses, too many fines in surface mixtures, too much asphalt, swelling of underlying courses, or settlement. Like cracks, distortion takes a number of different forms: grooves or ruts, shoving, corrugations, depressions, upheaval. As with any other defect, the type of distortion and its cause must be determined before the correct remedy can be applied. Repair techniques range from leveling the surface by filling with new material to complete removal of the affected area and replacing with new material.

2.18 CHANNELS (RUTS)—These are channelized depressions which may develop in the wheel tracks of an asphalt pavement, Figure II-44.

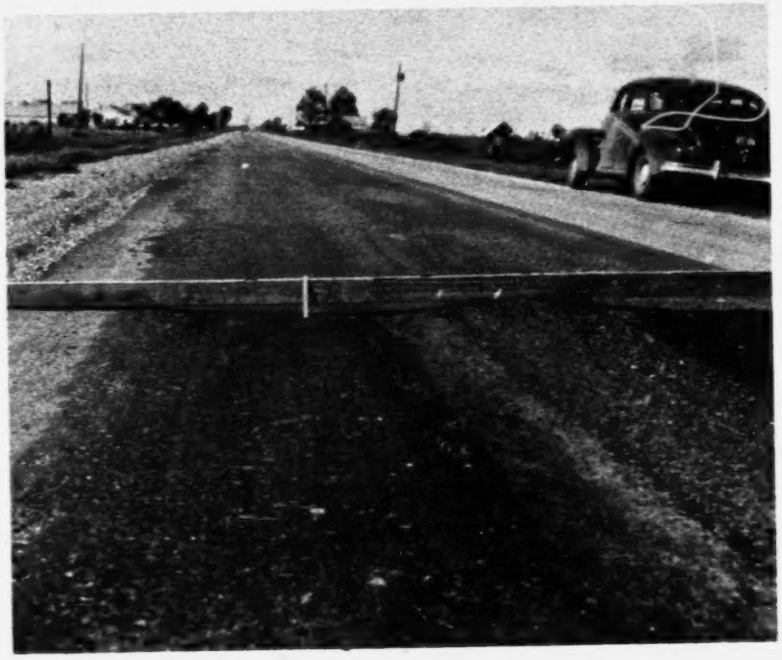

Figure II-44—Channels (ruts)

(1) *Cause*—Channels may result from consolidation or lateral movement under traffic in one or more of the underlying courses, or by displacement in the asphalt surface layer itself. They may develop under traffic in new asphalt pavements that had too little compaction during construction. They may develop from plastic movement in a mix that does not have enough stability to support the traffic.

(2) *Repair*—Level the pavement by filling the channels with hot plant-mixed asphalt material. Follow with a thin asphalt plant-mix overlay.

(a) Determine the limits of channels with a straightedge or stringline, Figure II-45. Outline with a crayon the areas to be filled.

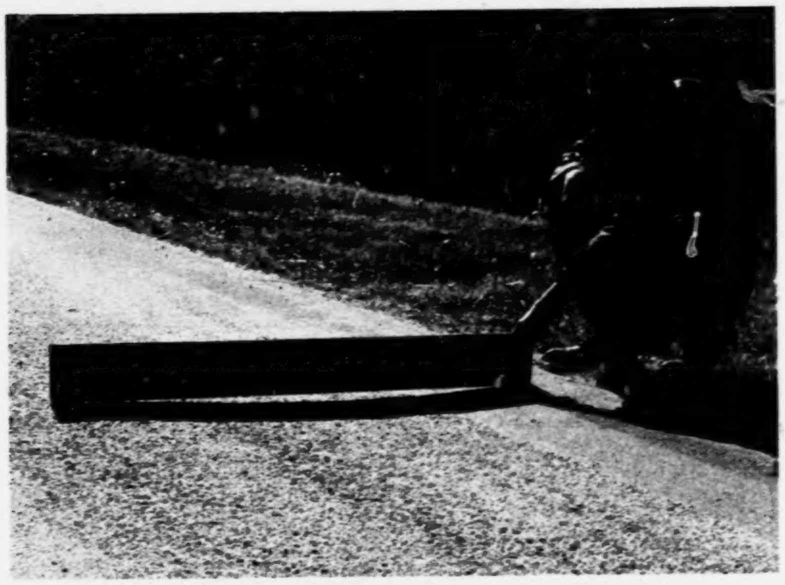

Figure II-45—Straightedging and outlining channel
(Photo courtesy North Carolina State Highway Commission)

(b) Apply a light tack coat (0.05 to 0.15 gallon per square yard of SS-1 or SS-1h asphalt emulsion diluted with equal parts of water). *See* Figure II-46.

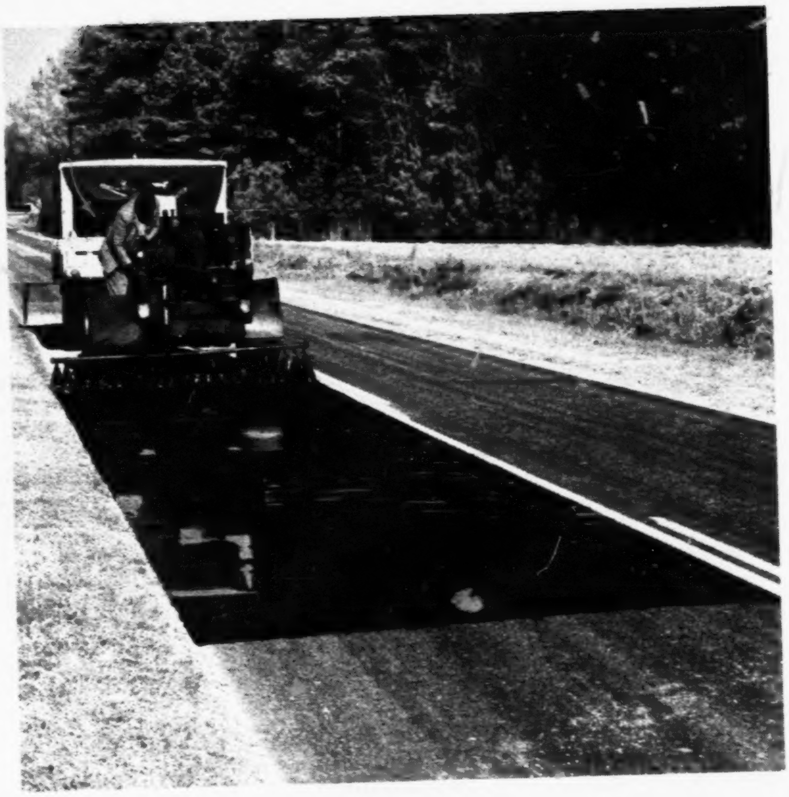

Figure II-46—Applying tack coat (*Photo courtesy North Carolina State Highway Commission*)

(c) Spread dense-graded asphalt concrete (Asphalt Institute Mix Type IVa or Type IVb) in the channels with a paver, Figure II-47. Be sure that the material is feathered at the edges.

(d) Compact with a pneumatic-tired roller. If one is not available, use a steel-wheeled roller, Figure II-48.

(e) Place a thin overlay of hot plant-mixed material, Figure II-49.

(f) If the pavement is not to be overlaid, place a sand seal over the patched areas to prevent the entrance of water, being careful not to apply too much asphalt.

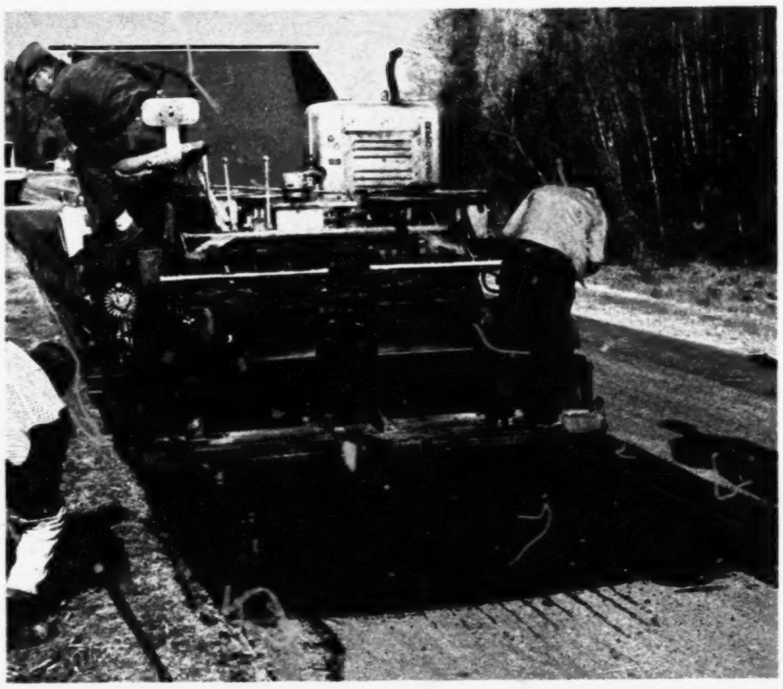

Figure II–47—Spreading dense-graded plant-mix (*Photo courtesy North Carolina State Highway Commission*)

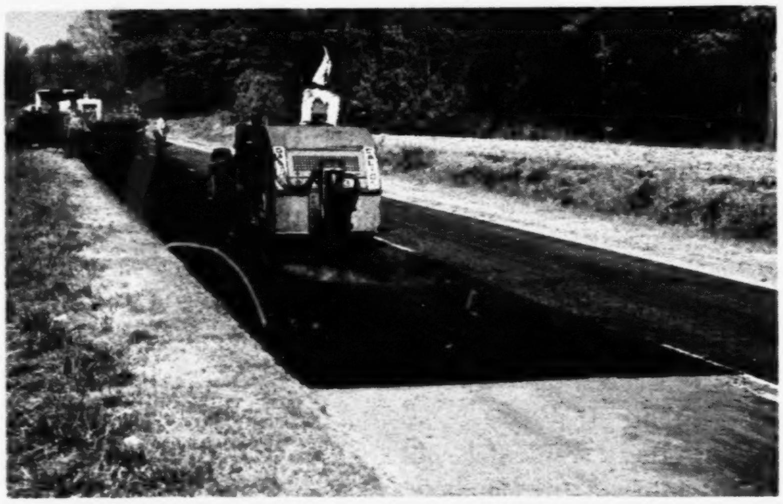

Figure II–48—Compacting with roller (*Photo courtesy North Carolina State Highway Commission*)

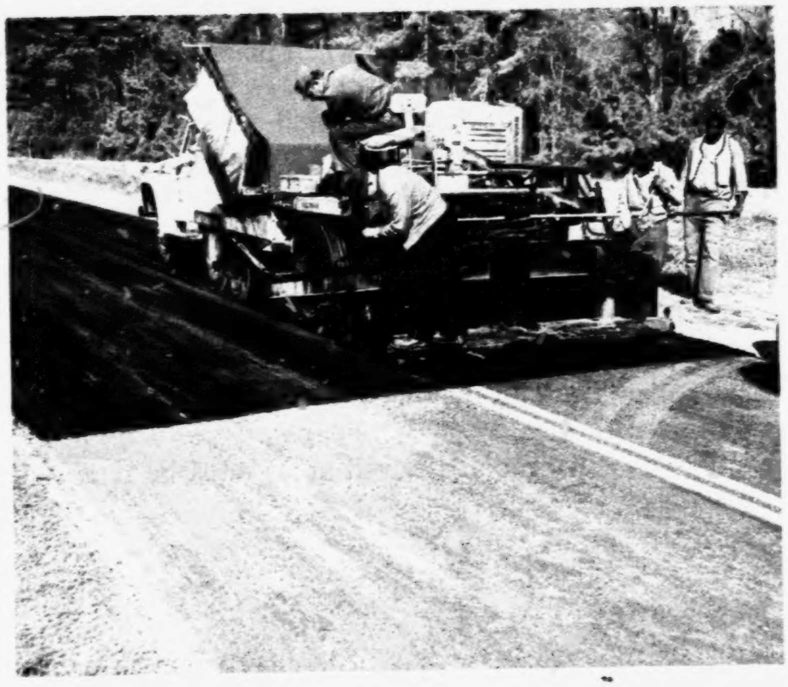

Figure II-49—Placing thin overlay of hot plant-mix material (*Photo courtesy North Carolina State Highway Commission*)

2.19 CORRUGATIONS AND SHOVING—Corrugations (sometimes called "washboarding") is a form of plastic movement typified by ripples across the asphalt pavement surface, Figure II-50. Shoving is a form of plastic movement resulting in localized bulging of the pavement surface, Figure II-51. These occur usually at points where traffic starts and stops, on hills where vehicles brake on the downgrade, on sharp curves, or where vehicles hit a bump and bounce up and down.

(1) *Cause*—Corrugations and shoving usually occur in asphalt layers that lack stability. Lack of stability may be caused by a mixture which is too rich in asphalt, has too high a proportion of fine aggregate, has coarse or fine aggregate which is too round or too smooth textured, or has asphalt cement which is too soft. It may

also be due to excessive moisture, contamination due to oil spillage, or lack of aeration when placing mixes using liquid asphalts.

(2) *Repair*—If the corrugated pavement has an aggregate base with a thin surface treatment, a satisfactory corrective measure is to scarify the surface, mix it with the base, and recompact the mixture before resurfacing.

If the pavement has more than 2 inches of asphalt surfacing and base, shallow corrugations can be removed with a pavement planing machine, better known as a "heater-planer." This is followed with a seal coat or plant-mixed surface.

For effective repair, shoved areas must be removed and patched.

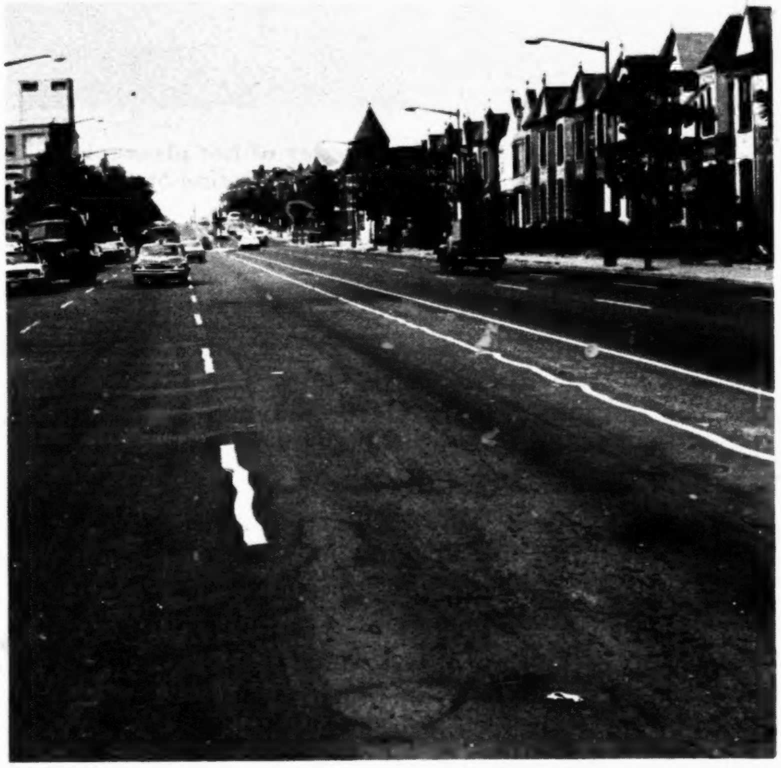

Figure II-50—Corrugations

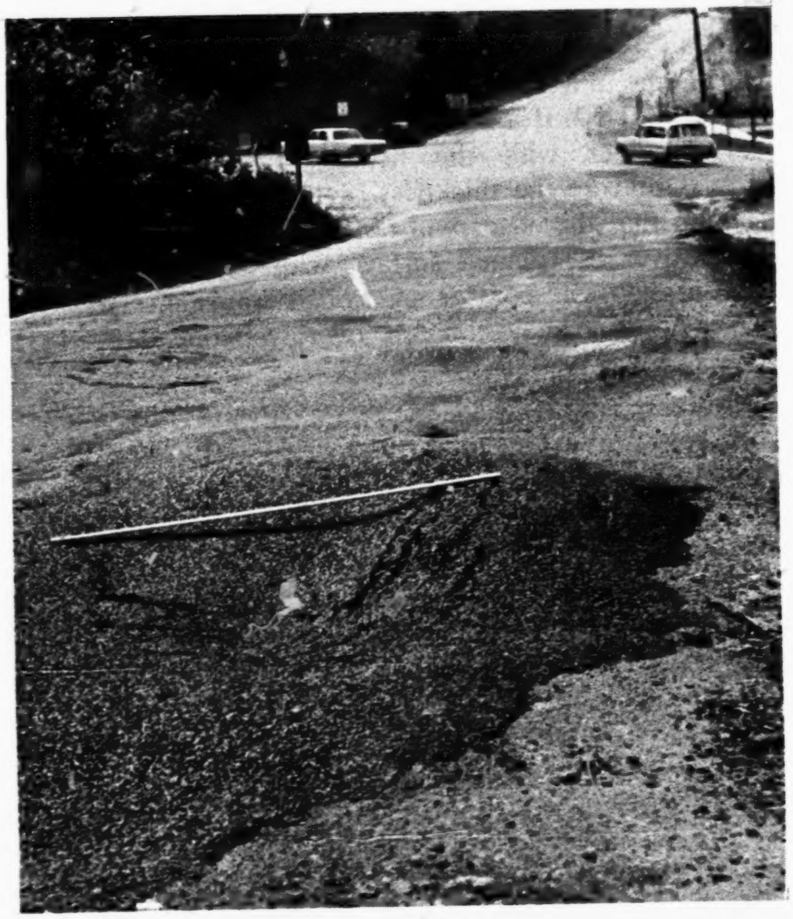

Figure II-51—Shoving

Repair of Corrugations in a Thin Surface Treatment:

(a) Scarify and break up the surface with a rotary tiller.
(b) Mix the broken-up surface material with the base material to a depth of 4 inches.
(c) Compact and reshape the base.
(d) Prime the base.
(e) Apply a new surface treatment.

Repair of Corrugations in a Thick Asphalt Surface:

(a) Plane to a smooth surface with a heater-planer, Figure II-52. If a paved gutter line must be met, cut a shoulder with the heater-planer. The shoulder should be the thickness of the seal coat to follow, so that the edges will not have to be feathered.

(b) Cover the planed surface with a hot plant-mixed asphalt seal coat or an asphalt emulsion slurry seal (or an asphalt concrete overlay if one is needed).

Repair of Shoved Areas—see Alligator Cracks—Deep Patch (Article 2.09)

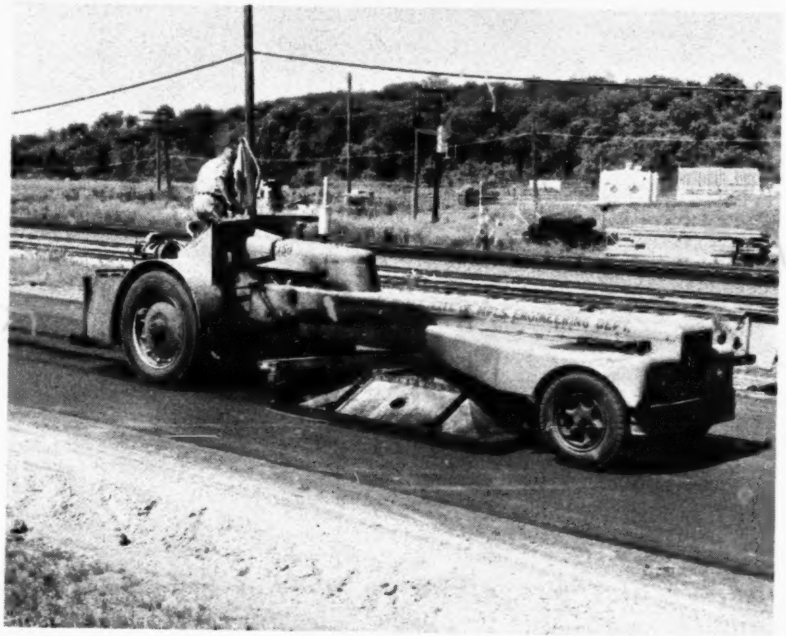

Figure II-52—Planing with a heater-planer

2.20 GRADE DEPRESSIONS—Depressions are localized low areas of limited size which may or may not be accompanied by cracking, Figure II-53. They dip an inch or more below grade and water will collect in them.

These "birdbaths" are not only a source of pavement deterioration but are a hazard to motorists, especially in freezing weather.

(1) *Cause*—Depressions may be caused by traffic heavier than that for which the pavement was designed, by settlement of the lower pavement layers, or by poor construction methods.

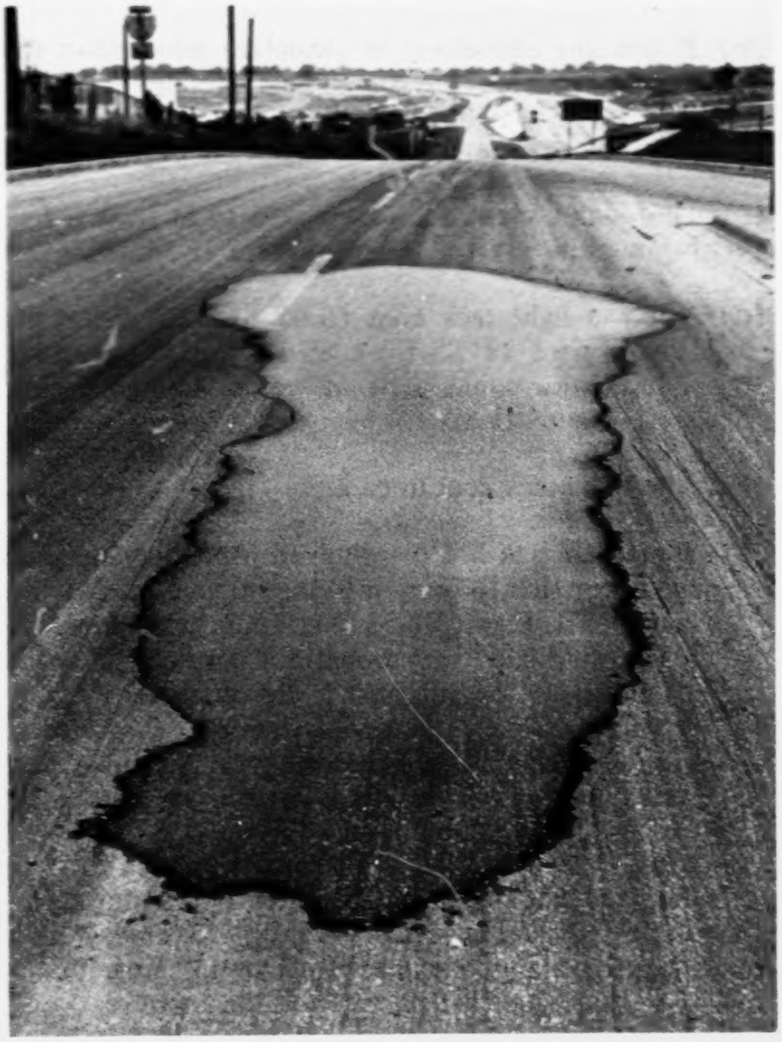

Figure II–53—Depression (depressed area is denoted by water lying on pavement)

(2) *Repair*—Depressions should be filled with hot plant-mixed asphalt material and compacted to bring them up to the same grade as the surrounding pavement.

(a) Determine the limits of the depression with a straightedge or stringline, Figure II-54. Outline it on the pavement surface with a marking crayon.

(b) If grinding equipment is available, grind down the area to provide a vertical face around the edge, Figure II-55. If this equipment is not available this step may be omitted.

(c) Thoroughly clean the entire area to at least a foot beyond the marked limits, Figure II-56.

(d) Apply a light tack coat (0.05 to 0.15 gallon per square yard of SS-1 or SS-1h asphalt emulsion diluted with equal parts of water) to the cleaned area, Figure II-57.

(e) Allow the tack coat to cure.

(f) Spread enough hot plant-mixed asphalt material in the depression to bring it to the original grade when compacted, Figure II-58. Plant mix with liquid asphalt (cold-laid) may be used if the hot mix is not available. If the mixture is the cold-laid type, it should be aerated thoroughly before it is placed in the depression. This is necessary to get rid of solvents and water that may cause an unstable patch.

(g) If the pavement was not ground down, the edges of the patch should be feather-edged by careful raking and manipulation of the material. However, in raking, care should be taken to avoid segregation of the coarse and fine particles of the mixture.

(h) Check the patch with a straightedge or a stringline, Figure II-59.

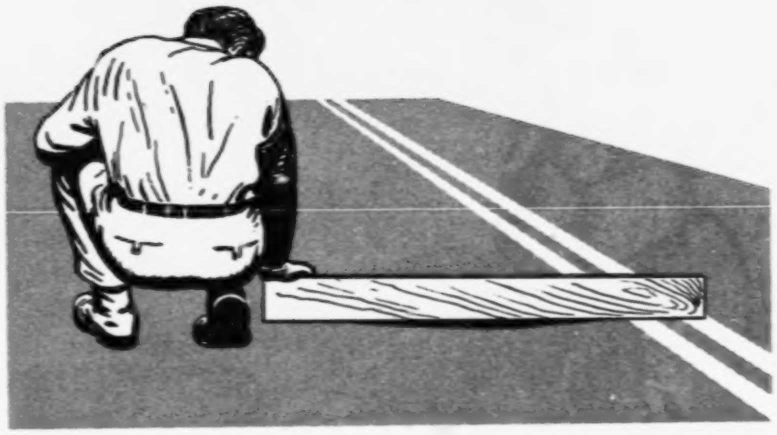

Figure II–54—Straightedging and outlining depression

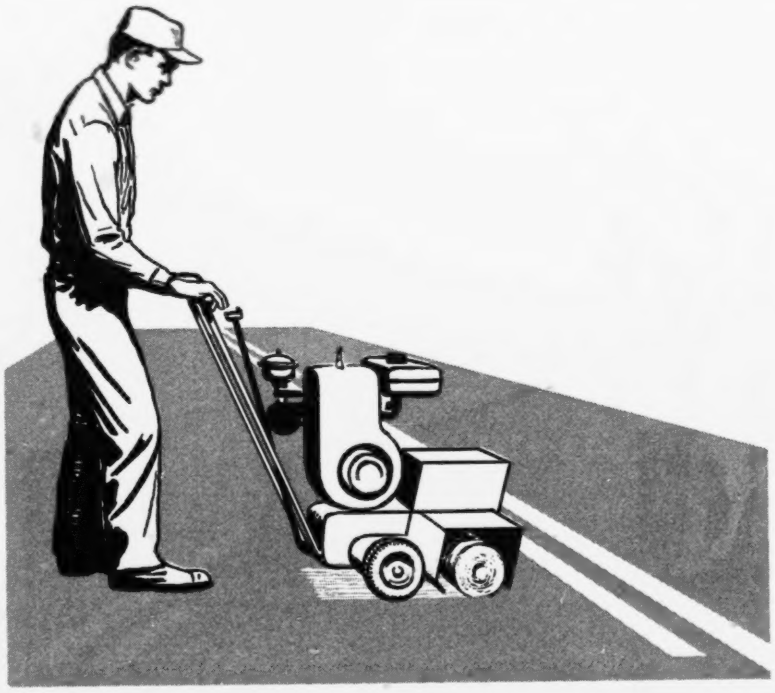

Figure II–55—Grinding down edge

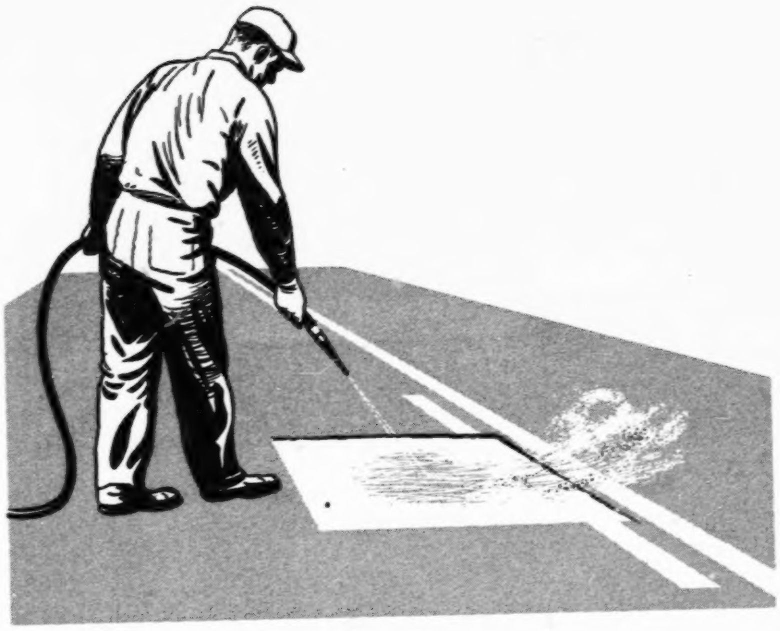

Figure II-56—Cleaning area

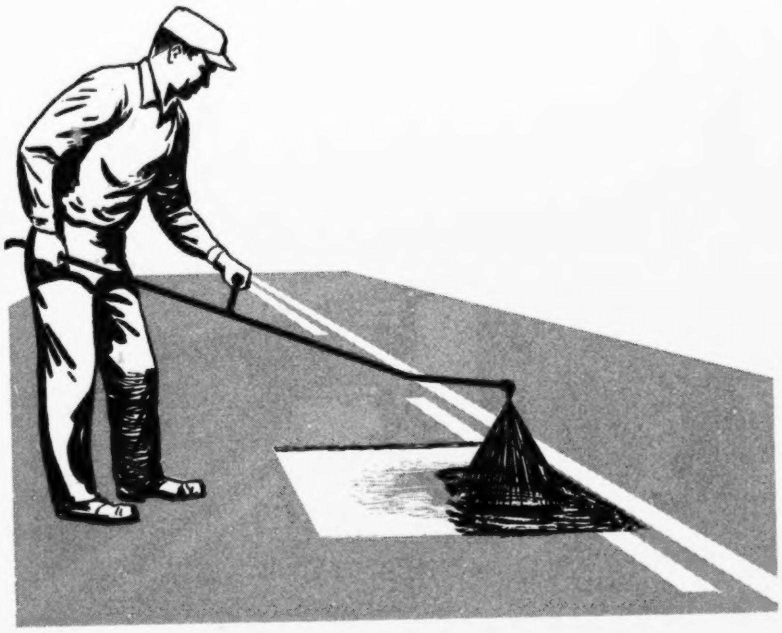

Figure II-57—Applying tack coat

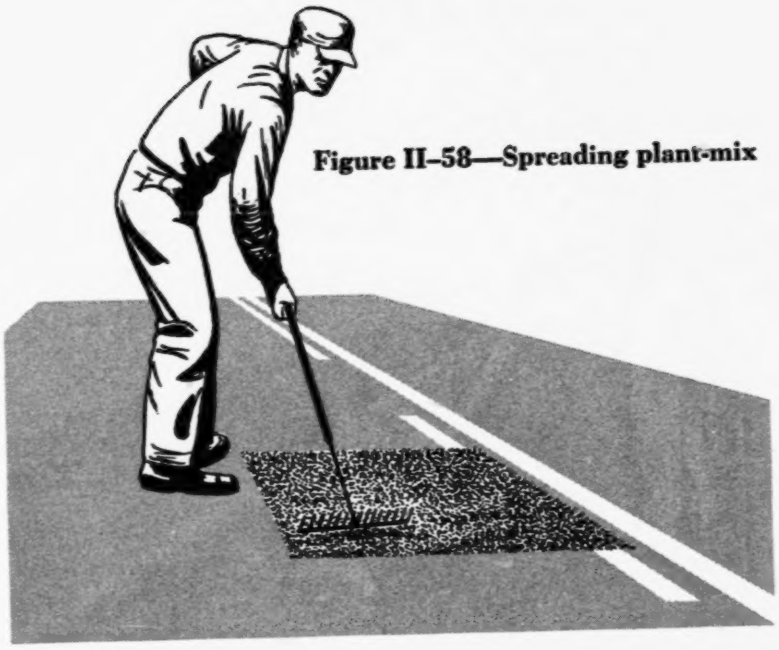

Figure II-58—Spreading plant-mix

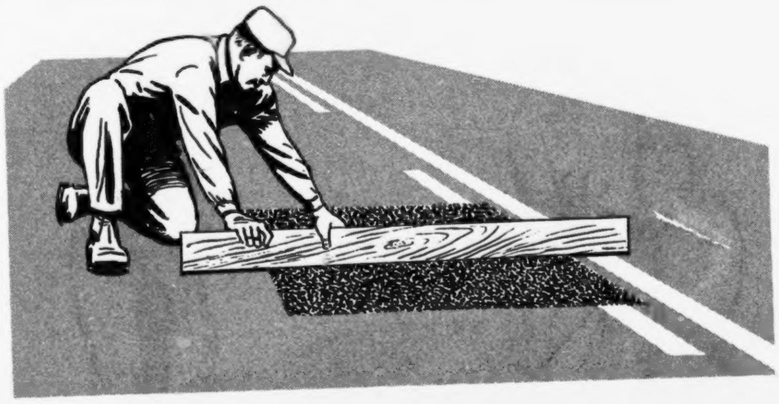

Figure II-59—Straightedging patch

(i) Thoroughly compact the patch with a vibratory plate compactor, roller, or hand tamps, Figure II-60.

(j) Place a sand seal on the patched area to prevent the entrance of water, Figure II-61. Do not apply too much asphalt.

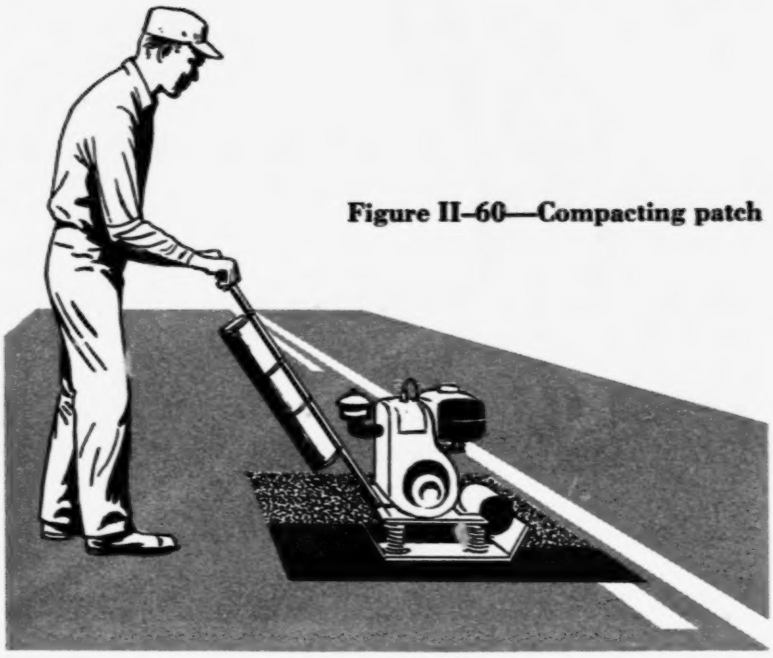

Figure II-60—Compacting patch

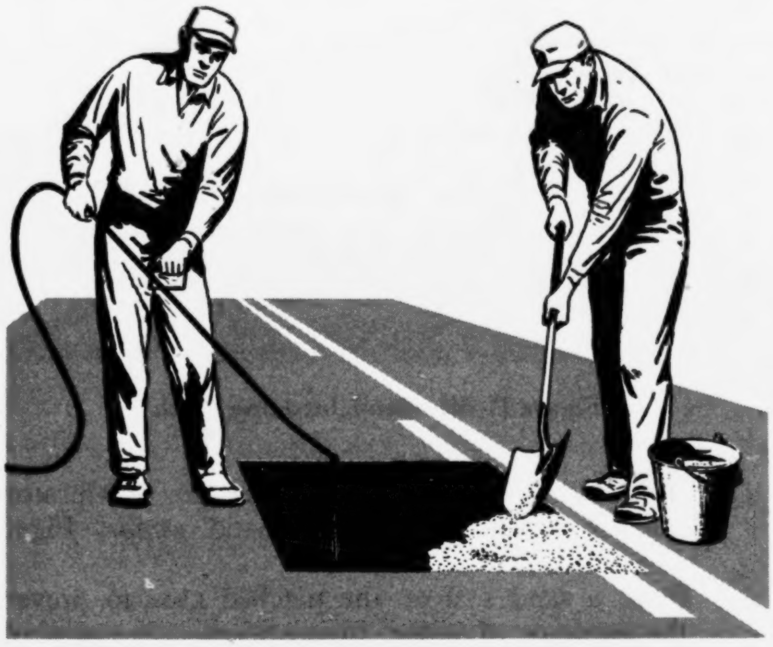

Figure II-61—Placing sand seal

2.21 UPHEAVAL—Upheaval is the localized upward displacement of a pavement due to swelling of the subgrade or some portion of the pavement structure, Figure II-62. Frost heaves are good examples.

(1) *Cause*—Upheaval is most commonly caused by expansion of ice in the lower courses of the pavement or the subgrade. But it may also be caused by the swelling effect of moisture on expansive soils.

(2) *Repair*—See *Alligator Cracks—Deep Patch* (Article 2.09).

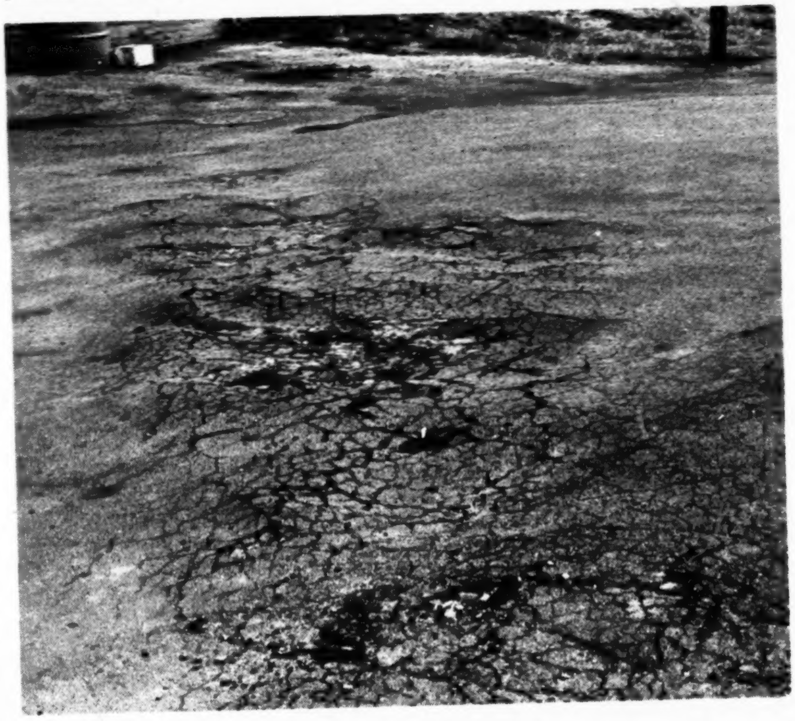

Figure II-62—Upheaval

2.22 UTILITY CUT DEPRESSIONS—Depressions in the pavement that develop from a cut for utility installation or repair, Figure II-63.

(1) *Cause*—These depressions usually are caused by lack of adequate compaction of backfill.

(2) *Repair*—See *Depressions* (Article 2.20).

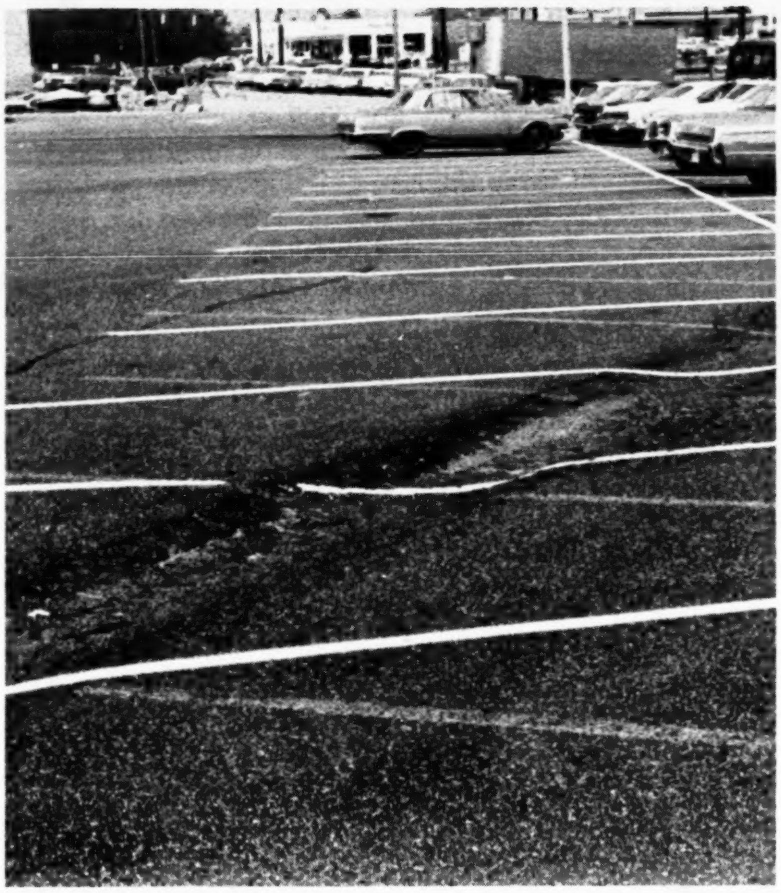

Figure II-63—Utility-cut depression

C. Disintegration

2.23 GENERAL—Disintegration is the breaking up of a pavement into small, loose fragments. This includes the dislodging of aggregate particles. If not stopped in its early stages, it can progress until the pavement requires complete rebuilding.

Two of the more common types of early-stage disintegration are pot holes and raveling. Repair ranges from simple seals to deep patches.

The repair techniques recommended in this section are not necessarily the only correct ways to do the job. They are, however, proven methods that will give satisfactory results.

2.24 POT HOLES—These are bowl-shaped holes of various sizes in the pavement resulting from localized disintegration, Figure II-64.

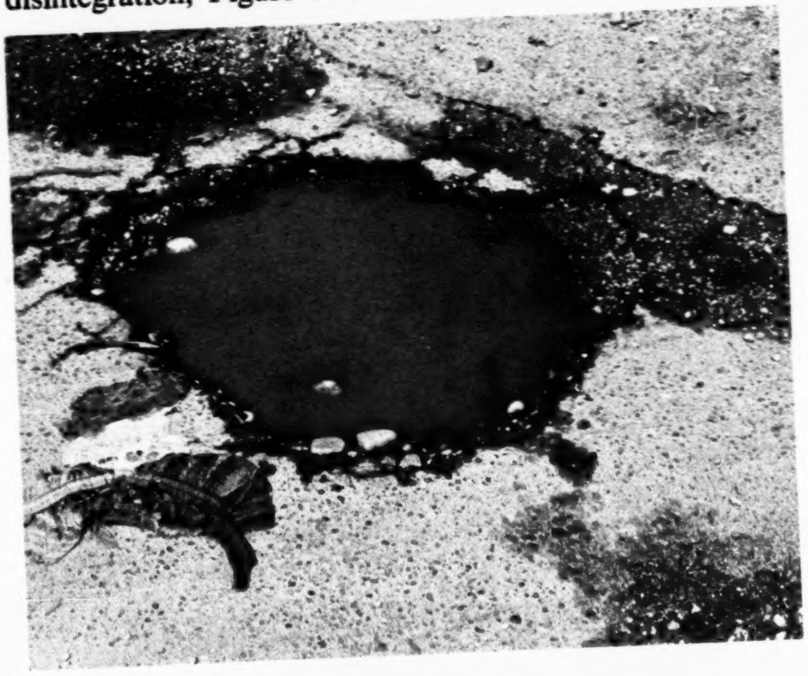

Figure II-64—Pot hole

(1) *Cause*—Pot holes are usually caused by weakness in the pavement resulting from such as too little asphalt, too thin an asphalt surface, too many fines, too few fines, or poor drainage.

(2) *Repair*—Pot holes frequently appear when it is difficult to make a permanent repair and emergency measures have to be taken. Temporary repair usually involves cleaning out the hole and filling it with a premixed asphalt patching material. Permanent repair is

made by cutting out the hole to solid material on both sides and bottom and filling it with new base and surface material, Figure II-65.

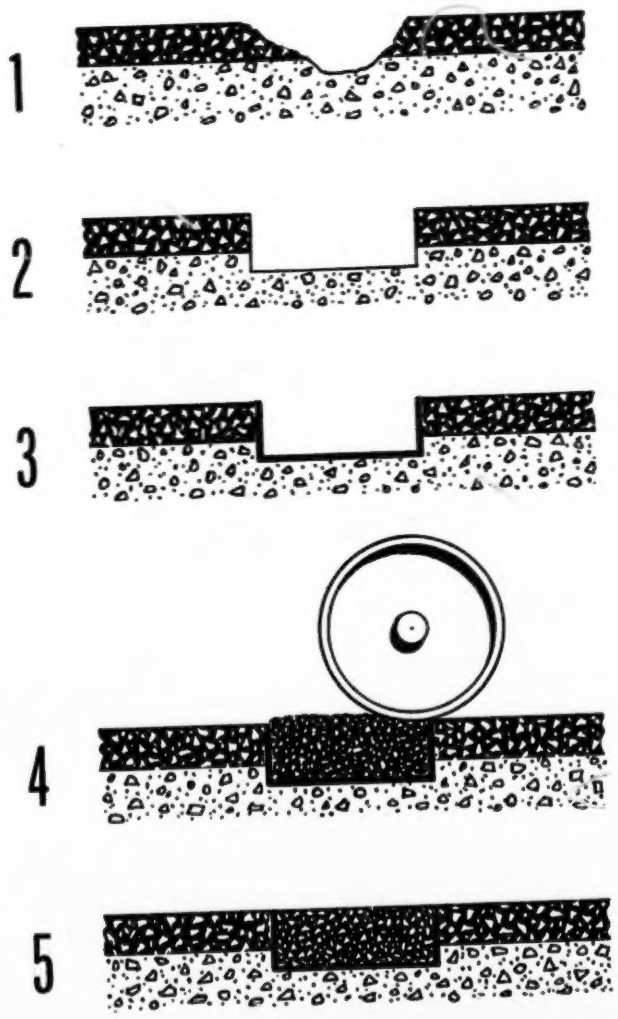

Figure II-65—Pot hole permanent repair. (1) Untreated pot hole, (2) Surface and base removed to firm support, (3) Tack coat applied, (4) Full-depth asphalt mixture placed and being compacted, (5) Finished patch compacted to level of surrounding pavement

Emergency Repair:

- (a) Clean hole of loose material and as much water as possible, Figure II-66.
- (b) Use infra-red heater to heat and soften asphalt surfacing surrounding hole, Figure II-67.
- (c) Fill hole with asphalt emulsion stockpile mixture and rake smooth, Figure II-68.
- (d) Compact with vibratory plate compactor or roller, Figure II-69.
- (e) Dry compacted patch with infra-red heater, Figure II-70.

Permanent Repair: See *Alligator Cracks—Deep Patch* (Article 2.09).

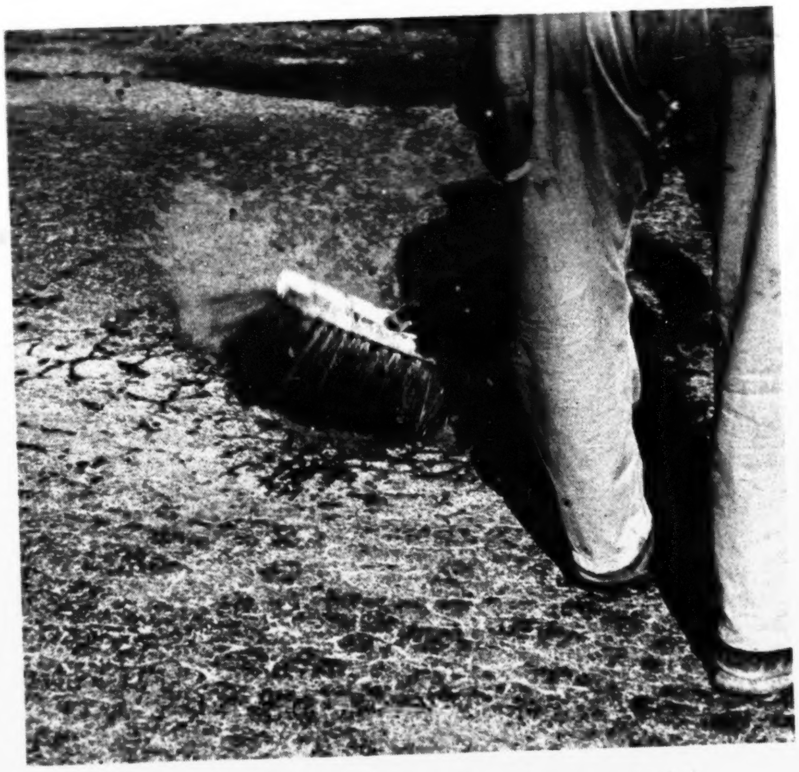

Figure II-66—Cleaning hole of loose material

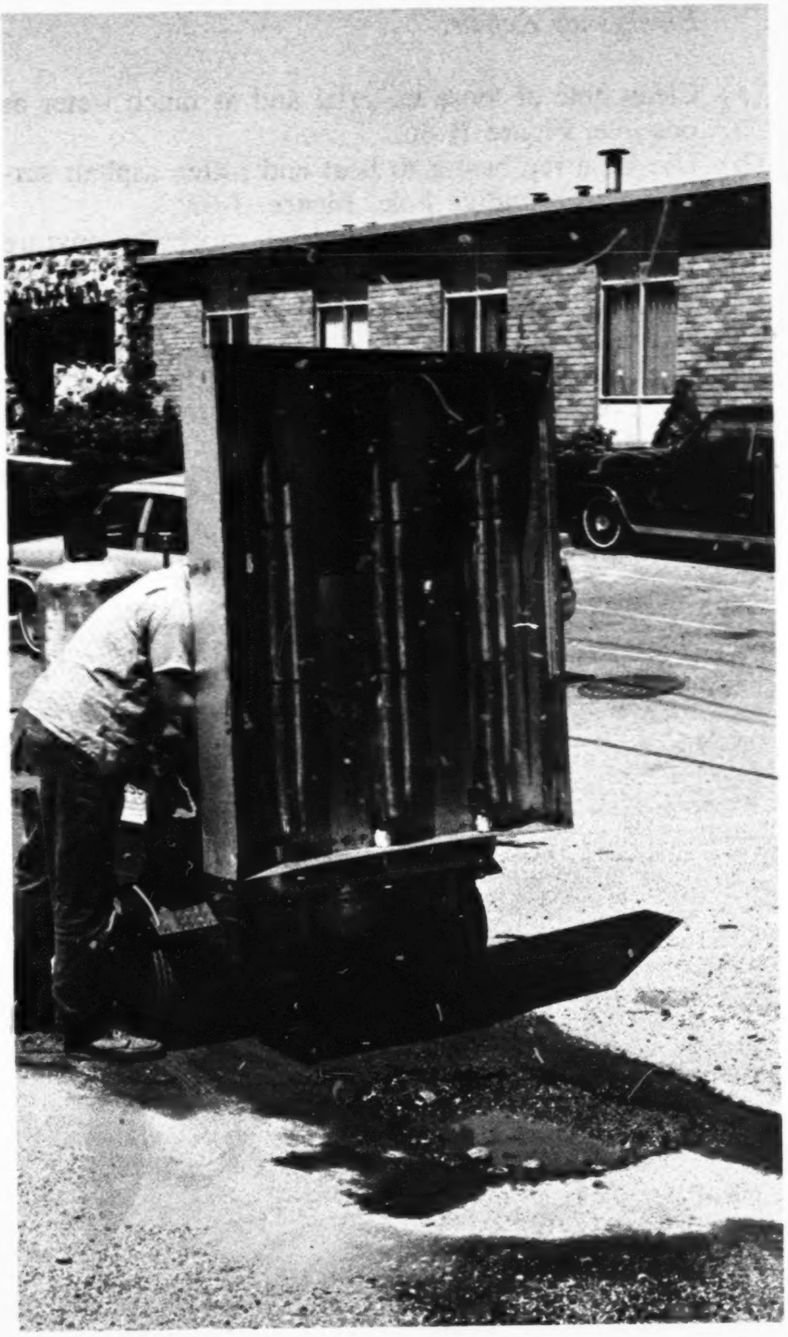

Figure II–67—Using infra-red heater

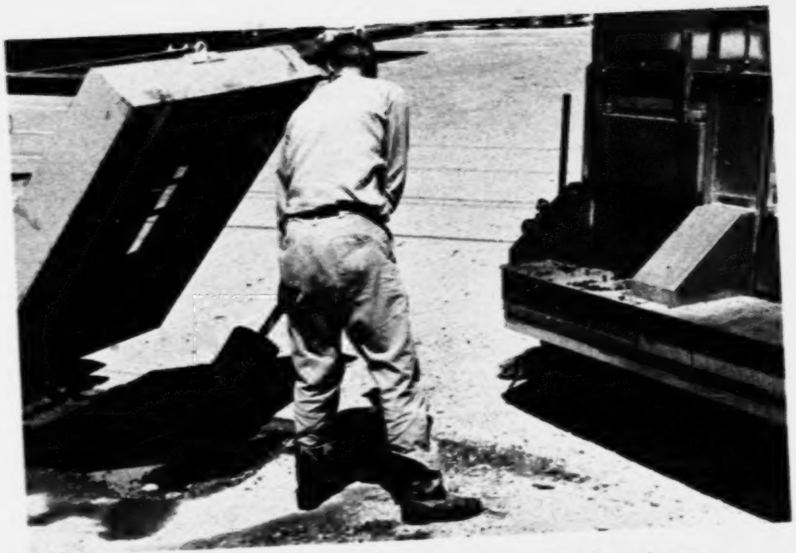

Figure II–68—Filling hole with stockpile mixture

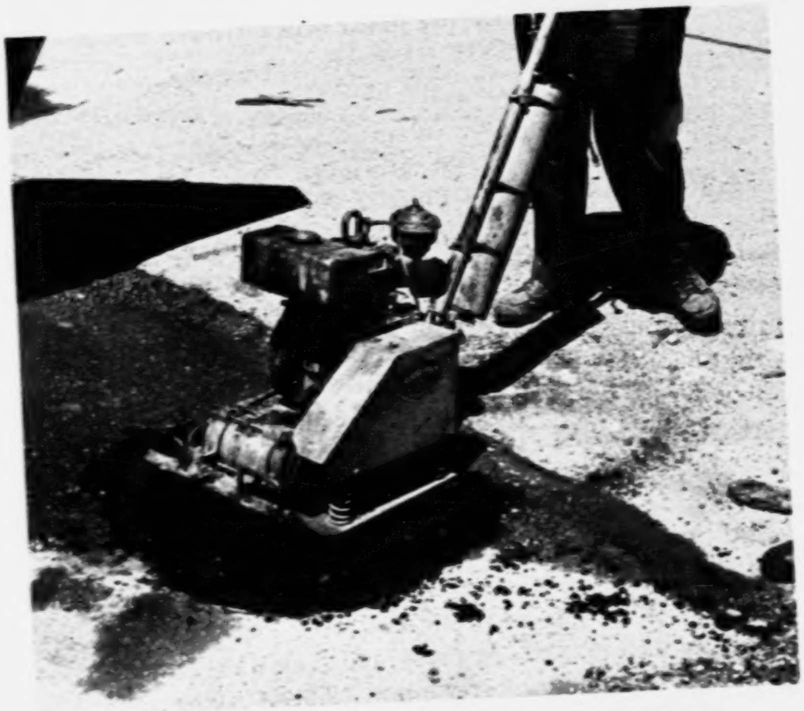

Figure II–69—Compacting with vibratory plate compactor

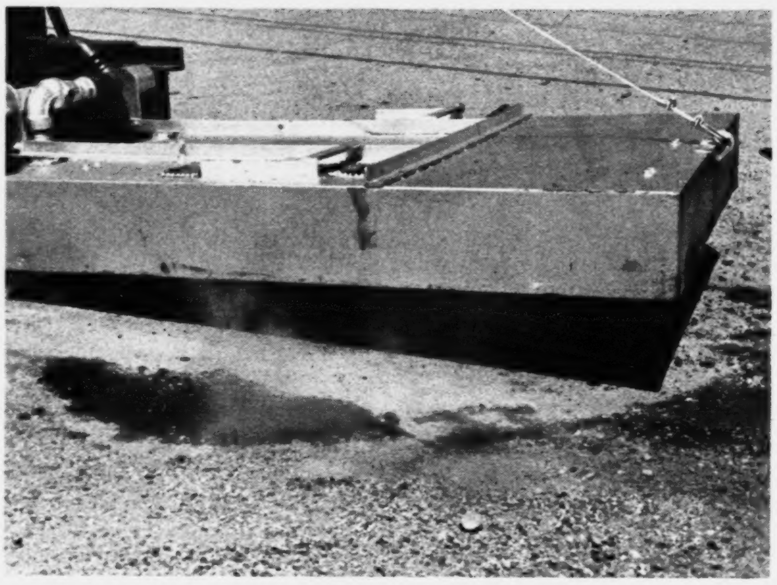

Figure II–70—Drying patch with infra-red heater

2.25 RAVELING—This is the progressive separation of aggregate particles in a pavement from the surface downward or from the edges inward, Figure II-71. Usually, the fine aggregate comes off first and leaves little "pock marks" on the pavement surface. As the erosion continues, larger and larger particles are broken free and the pavement soon has the rough and jagged appearance typical of surface erosion.

(1) *Cause*—Raveling is caused by lack of compaction during construction, construction during wet or cold weather, dirty or disintegrating aggregate, too little asphalt in the mix, or overheating of the asphalt mix.

(2) *Repair*—Raveling surfaces, dry and weathered surfaces, and porous surfaces are conditions which usually require a surface treatment. These treatments may be looked upon either as corrective maintenance or as preventive maintenance. In the former case they are

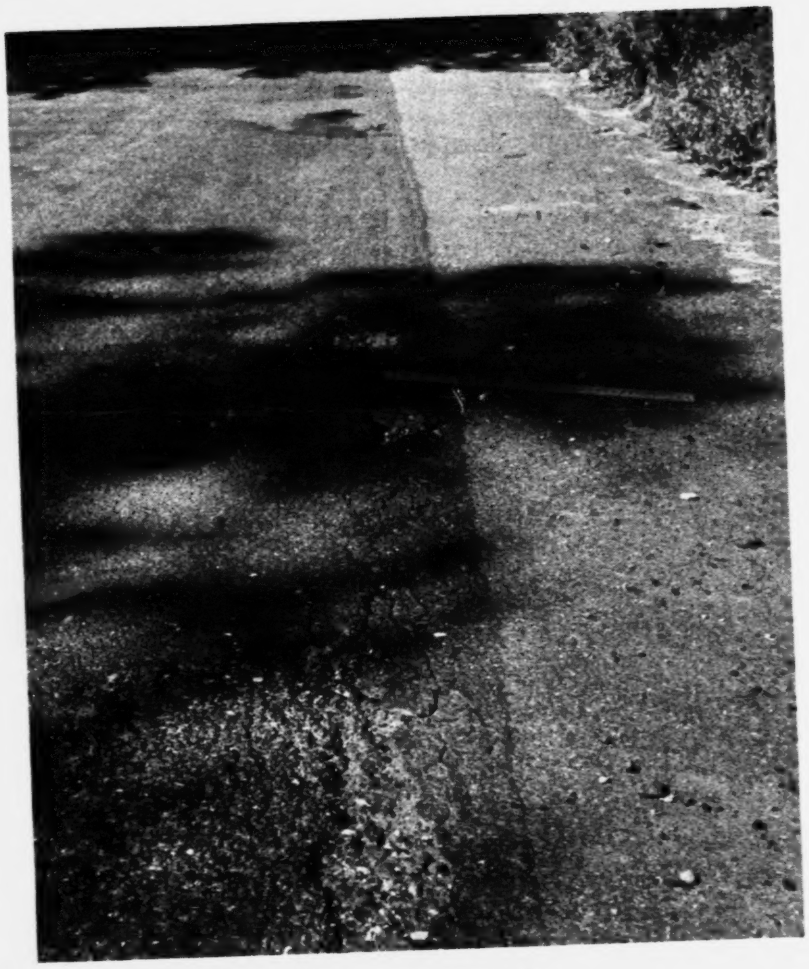

Figure II–71—Raveling

used to correct an existing condition. In the latter case they are used in an effort to prevent an anticipated condition from becoming a reality.

Emergency Repair:

(a) Sweep the surface free of all dirt and loose aggregate material.

(b) Apply a fog seal (0.1 to 0.2 gallon per square yard, depending upon the texture and porosity of the pavement, of SS-1h or SS-Kh asphalt emulsion diluted with equal parts of water). Cover aggregate is not required.

(c) Close to traffic until seal has cured.

Permanent Repair:

(a) Same as (a), (b), and (c) for Emergency Repair.

(b) Apply a surface treatment (slurry seal, sand seal, aggregate seal, or plant-mixed surface treatment, depending on the condition of the surface and the amount of traffic). See *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13), The Asphalt Institute, for information on how to get a good surface treatment.

D. Skid Hazard

2.26 GENERAL—Few dry pavements are slippery. But there are a number of things that can make a pavement slippery when wet. One of the most frequent causes of slippery asphalt pavements is a thin film of water on a smooth surface. Another is a thick film of water which, at high speeds, causes the vehicle to leave the pavement surface and skim over the water like an aquaplane. The smooth pavement condition usually is the result of a film of asphalt on the surface, or polished aggregate in the surface course. Slipperiness may also develop from surface contamination, such as from oil spillage or certain types of clay. The object of skid hazard improvement is to restore the pavement surface to a condition where water can flow around most of the surface aggregate particles, leaving contact between tire and aggregate. Treatment ranges from cleaning the surface of contamination to removal of excess asphalt and resurfacing to improve surface drainage.

2.27 BLEEDING OR FLUSHING ASPHALT—Bleeding, or flushing, is the upward movement of asphalt in an asphalt pavement resulting in the formation of a film of asphalt on the surface, Figure II-72.

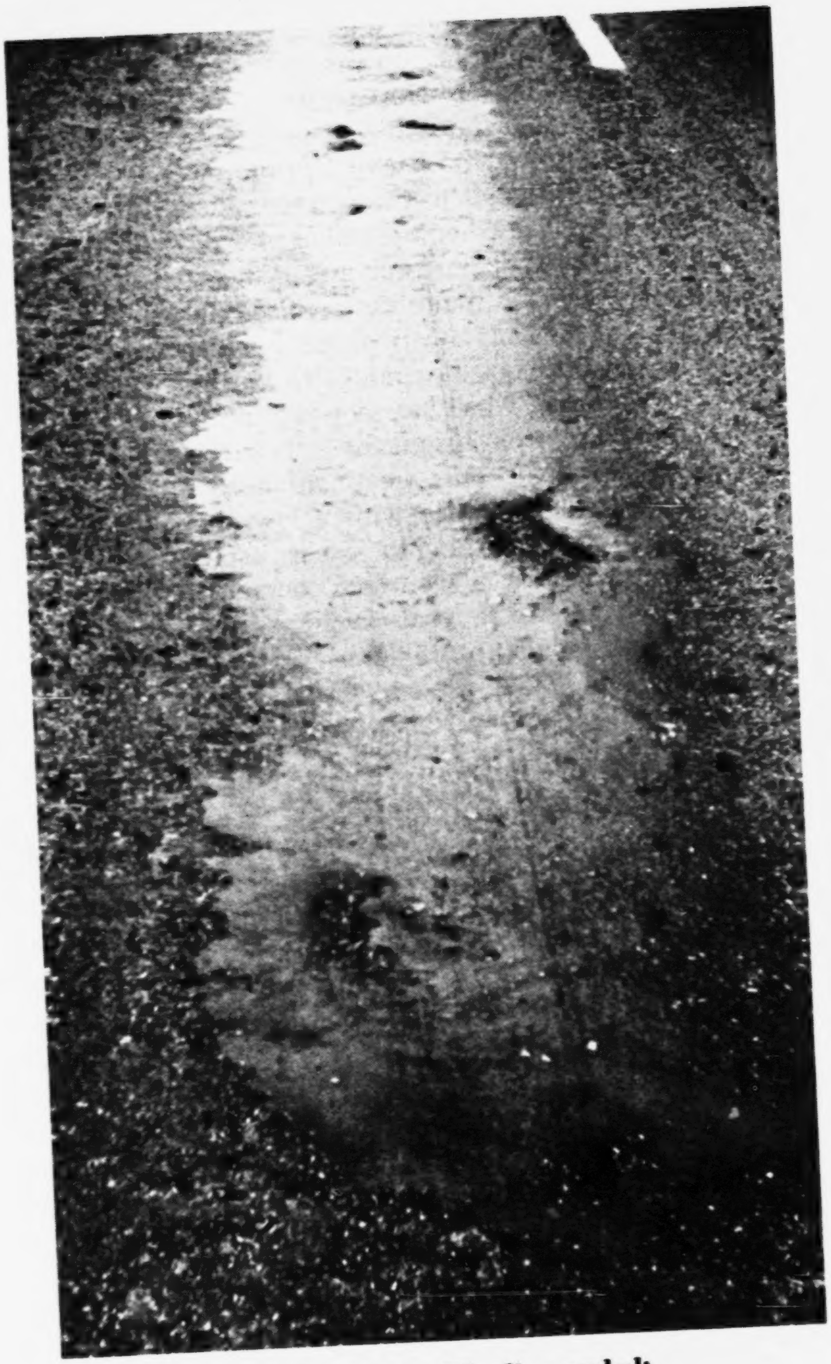

Figure II–72—Bleeding asphalt

(1) *Cause*—The most common cause of bleeding, or flushing, which usually occurs in hot weather, is too much asphalt in one or more of the pavement courses. This can result from too rich a plant mix, an improperly constructed seal coat, too heavy a prime or tack coat, or solvent carrying asphalt to the surface. Also, overweight traffic may cause added compression of a pavement, containing too much asphalt, forcing it to the surface.

(2) *Repair*—In many cases, bleeding can be corrected by repeated applications of hot sand, hot slag screenings, or hot rock screenings to blot up the excess asphalt. Sometimes, when bleeding is light, a plant-mixed surface treatment or an aggregate seal coat, using absorptive aggregate, is the only treatment needed. Or a hot plant-mixed leveling course with a low asphalt content can be effective in absorbing the excess asphalt. With this treatment, however, a new surface course is needed over the leveling course to prevent raveling.

A pavement planing machine, such as a heater-planer, will remove the excess asphalt. Or in rare instances of heavily over-asphalted surfaces, the surfaces should be completely removed.

Repair with Hot Aggregate:

(a) Apply ⅜-inch maximum size slag screenings, sand, or rock screenings to the affected area. The aggregate should be heated to at least 300°F and spread at the rate of 10 to 15 pounds per square yard.
(b) Immediately after spreading, roll with a rubber-tired roller.
(c) When the aggregate has cooled, broom off loose particles.
(d) Repeat the process, if necessary.

Repair with a Heater-Planer:

(a) Remove the asphalt film with a heater-planer, Figure II-73.
(b) Leave the surface as planed, or
(c) Apply either a plant-mixed surface treatment or a seal coat, Figure II-74.

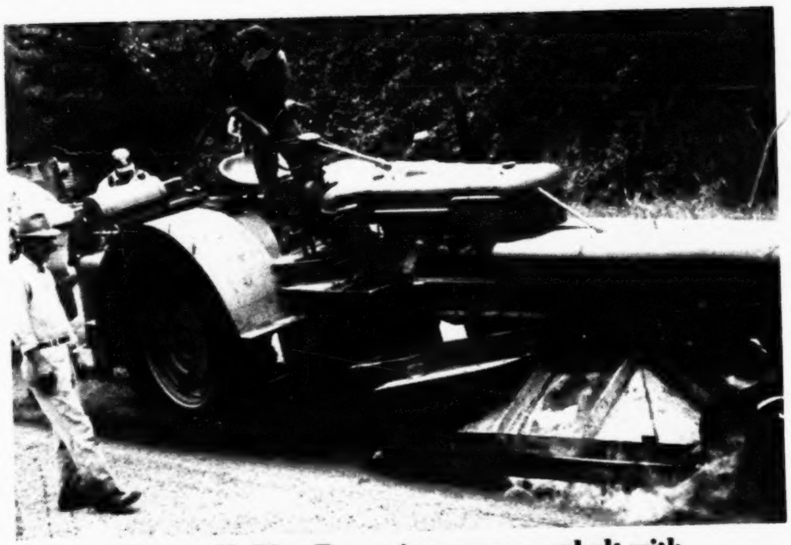

Figure II–73—Removing excess asphalt with heater-planer

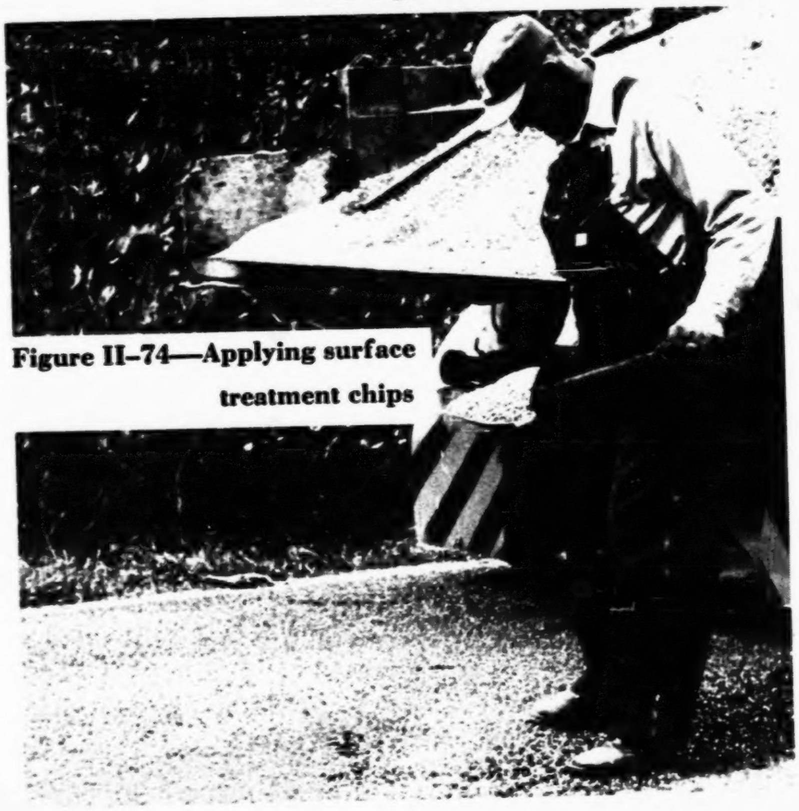

Figure II–74—Applying surface treatment chips

2.28 POLISHED AGGREGATE—These are aggregate particles in the surface of a pavement that have been polished smooth, Figure II-75. This includes both naturally smooth uncrushed gravels and crushed rock that wears down quickly under the action of traffic.

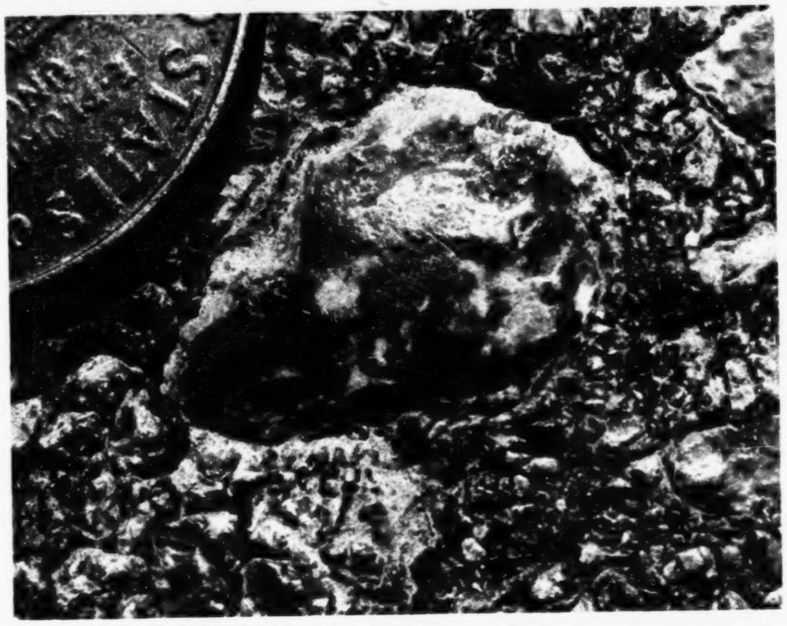

Figure II-75—Polished aggregate in pavement surface

(1) *Cause*—Some aggregates, particularly some types of limestone, will become polished rather quickly under traffic. Others, such as some types of gravel are naturally polished and if they are used in a pavement surface without crushing they will be a skid hazard. These polished aggregates are quite slippery when wet.

(2) *Repair*—The only effective way to repair a pavement with polished aggregates is to cover the surface with a skid resistant treatment. A hot plant-mixed surface treatment, a sand seal, or an aggregate seal should be applied. The aggregate must be hard and angular, such as slag silica sand, or other proven non-polishing material.

Plant-mixed Surface Treatment:

(a) Apply a light tack coat (0.05 to 0.15 gallon per square yard of SS-1 or SS-1h asphalt emulsion diluted with equal parts of water), Figure II-89.

(b) Spread hot plant-mixed material (Asphalt Institute Mix Type IIa or IIb) using aggregate such as crushed slag or silica sand, Figure II-76. If the hot plant-mixed material is not available, a sand or an aggregate seal may be used.

(c) Roll with rubber-tired and steel-wheeled rollers, Figure II-77.

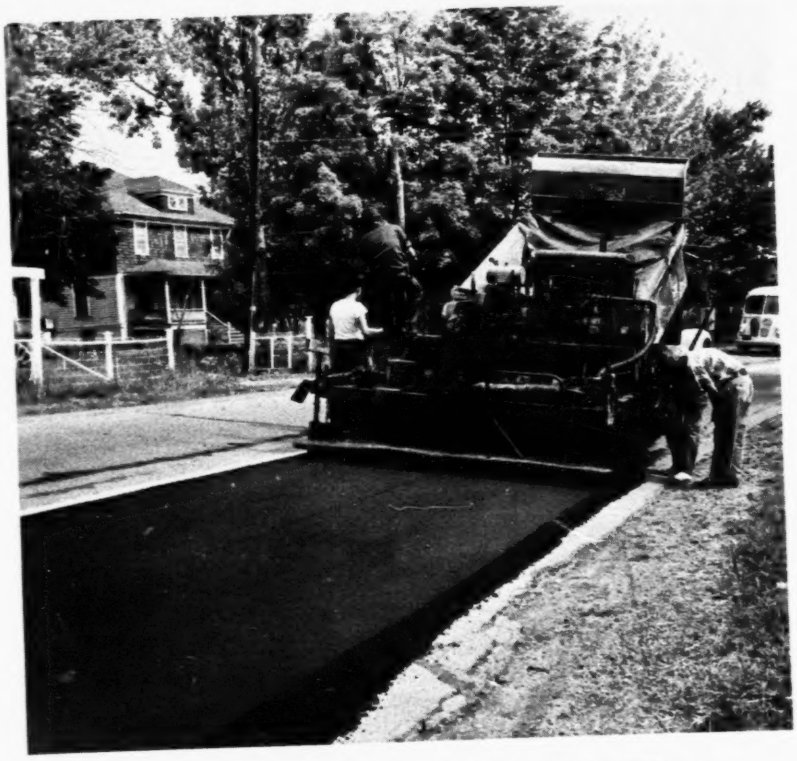

Figure II–76—Spreading hot plant-mix (*Photo courtesy* Constructioneer *magazine, New Jersey*)

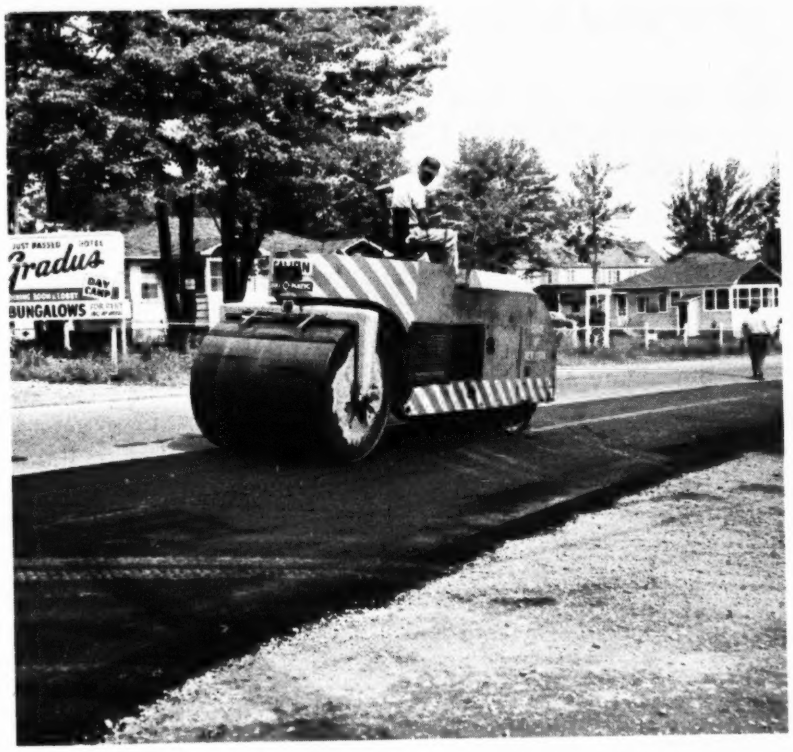

Figure II-77—Compacting with steel-wheeled roller (*Photo courtesy* Constructioneer *magazine, New Jersey*)

E. Surface Treatment—Special Problems

2.29 GENERAL—Because of the method of construction, surface treatments may develop some defects that do not occur in other types of asphalt pavement surfaces. These include loss of cover aggregate and streaking.

Some of the other asphalt pavement defects described earlier in this chapter—corrugations, depressions, upheaval, pot holes, and raveling—occur most frequently in pavements constructed by surface-treated methods. This happens because the thin asphalt surfacing usually is placed over an underdesigned pavement structure.

2.30 LOSS OF COVER AGGREGATE—The whipping-off of aggregate under traffic from a surface-treated pavement, leaving the asphalt, Figure II-78.

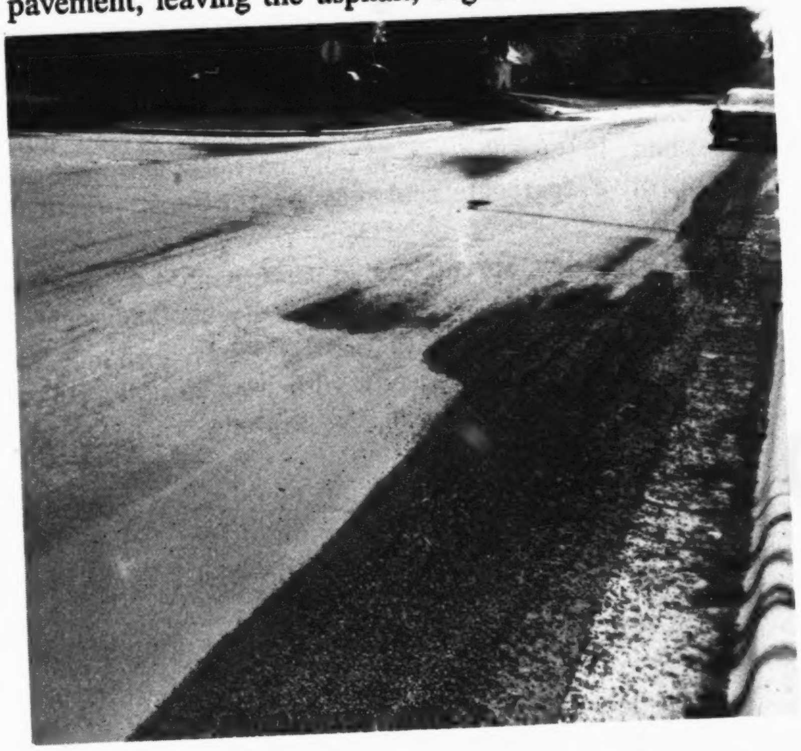

Figure II-78—Loss of cover aggregate

(1) *Cause*—Several things can cause the loss of cover aggregate. If the aggregate is not spread immediately (within one minute) after the asphalt is applied to the pavement surface the asphalt may have cooled too much to hold it. If the aggregate is too dusty or too wet when spread the asphalt may not be able to hold it under traffic. If the freshly-spread aggregate is not rolled immedately after placing it may not become seated in the asphalt sufficiently to hold under traffic. Or, if a steel-wheeled roller alone is used for compaction, aggregate may be lost from low spots that are bridged over by the roller. Other reasons are: weather too cool when

treatment was applied; fast traffic too soon on the new surface treatment; and a surface which absorbs part of the asphalt leaving too little to hold the aggregate.

(2) *Repair*—Hot coarse sand, spread over the affected areas, may be used to replace the lost aggregate. After spreading, it should be rolled *immediately* with a pneumatic-tired roller so that it will be seated into the asphalt. If the aggregate is only partially whipped-off an absorptive aggregate seal may be the most practical treatment.

(a) On a hot day, spread coarse sand, heated to at least 300°F, over the area that has lost cover aggregate.
(b) Follow *immediately* (before sand has a chance to cool even a few degrees) with a pneumatic roller to seat the aggregate in the asphalt.

2.31 LONGITUDINAL STREAKING—Alternating lean and heavy lines of asphalt running parallel to the centerline of the road, Figure II-79.

(1) *Cause*—Several things can cause longitudinal streaking:

(a) Spray bar on the asphalt distributor not set at the correct height for the spray fans to overlap properly.
(b) Spray bar rising as load in distributor lightens.
(c) Nozzle on spray bar not set at correct angle, not all set at same angle, are the wrong size, differ in size, some plugged with cold asphalt, or have imperfections.
(d) Wrong asphalt pump speed.
(e) Too cold asphalt.
(f) Too low a pump pressure.

A single centerline streak may be caused by too little asphalt or too cold asphalt at the matching joint between two applications.

(2) *Repair*—About the only satisfactory repair for longitudinal streaking is to plane off the streaked sur-

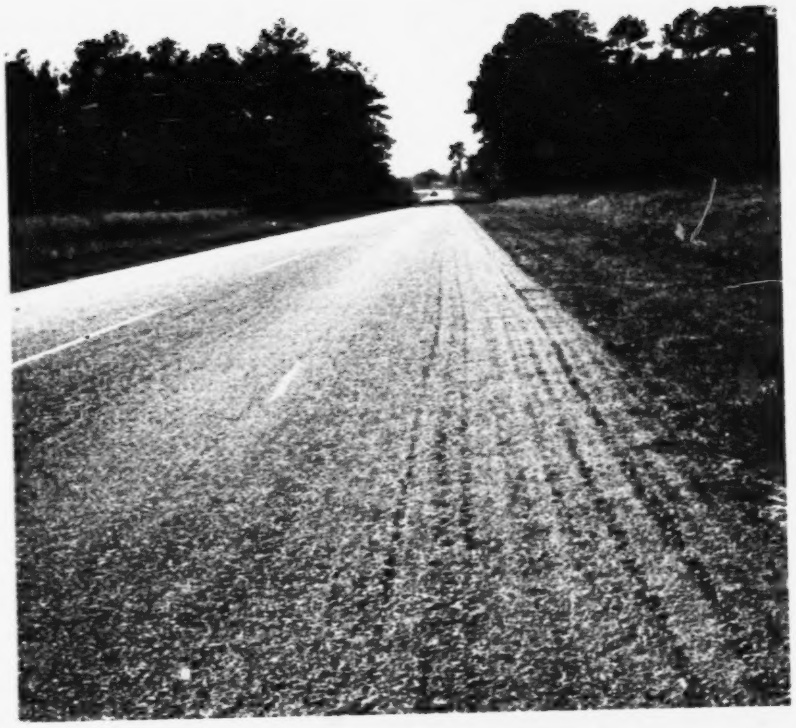

Figure II–79—Longitudinal streaking

face and apply a new surface treatment. It is much easier to prevent longitudinal streaking than to correct it. Careful adherence to the manufacturer's recommendations for the asphalt distributor before it is used and while it is being used will forestall streaking. *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13), The Asphalt Institute, also recommends a number of checks to assure proper operation of the asphalt distributor.

2.32 TRANSVERSE STREAKING — Alternating lean and heavy lines of asphalt running across the road which may result in corrugations in the pavement surface.

(1) *Cause*—Transverse streaking is caused by

spurts in the asphalt spray from the distributor spray bar. These spurts may be produced by pulsation of the asphalt pump due to worn or loose parts, by improper pump speed, or by a miss in the motor.

(2) *Repair*—See *Corrugations* (Article 2.19), and *Longitudinal Streaking* (Article 2.31).

Chapter III

ASPHALT IN THE MAINTENANCE OF PORTLAND CEMENT CONCRETE PAVEMENTS

3.01 ASPHALT FOR PCC MAINTENANCE—Asphalt has an important role in the maintenance of portland cement concrete pavements. It seals joints and cracks. It fills cavities and raises sunken slabs. It renews disintegrating pavements and covers slick surfaces. More specifically, asphalt and asphalt mixtures are used in the maintenance of portland cement concrete pavements to:

Restore design grade and surface smoothness.
Repair and retard spalling, scaling, and other deterioration.
Repair badly broken areas.
Improve skid resistance.
Protect and preserve the original joint filler.
Keep foreign material out of joints and cracks.
Keep water out of the base.
Prevent pumping and stabilize the subgrade.
Stop slab rocking.
Prevent damage from frost action.
Stop disintegration from use of de-icing chemicals.

Asphalt, then, can do an excellent job in repairing many defects in portland cement concrete pavements, but only if used correctly. The techniques discussed in this chapter are not the only correct ones. But they are methods that have been proven satisfactory by use.

For discussions of patching mixtures, tack coats, placing patching mixtures, and compacting patches see Chapter II.

3.02 JOINT AND CRACK SEALING—Joint and crack sealing is done for several reasons: it prevents surface water seepage, it protects joint fillers, and it keeps out foreign matter. At one time penetration-grade asphalt, alone or with filler added, was the sealing material most commonly used. It still is used in many places. But in recent years, rubber-asphalt compounds have gained favor because, among other advantages, they have less tendency to become brittle in cold weather and to soften and track under traffic in hot weather. Table III-1 lists several types of rubber-asphalt joint and crack sealers.

Table III-1

ASPHALTIC JOINT AND CRACK SEALERS FOR PORTLAND CEMENT CONCRETE PAVEMENTS

Material	Type	Specification		
		Federal	ASTM	AASHO
Rubber-asphalt	Cold-applied	SS-S-156	D 1850	—
Rubber-asphalt	Cold-applied mastic	SS-S-159b	D 1850	—
Rubber-asphalt	Hot-applied	SS-S-164	D 1190	M 173

The equipment used for sealing joints and cracks varies from small hand-pouring pots to truck- or trailer-mounted pressure applicators. Hand-pouring pots normally are refilled from a central heating kettle. When heating kettles are used they should be the double-jacketed, oil-bath type to avoid damage of the sealer by overheating. With rubber-asphalt compounds the heating kettles must be of this type.

Hand pouring-pots are used with heating kettles. To prevent overfilling of the joint or crack a squeegee should be used. A squeegee of the type shown in Figure III-1, used properly, will assure a neat job.

Truck- or trailer-mounted pressure applicators will handle either hot or cold applied sealing materials, Figure III-2. They have control valves and are equipped with nozzles of the size and shape needed to convey the sealing material into the opening. This type of equipment

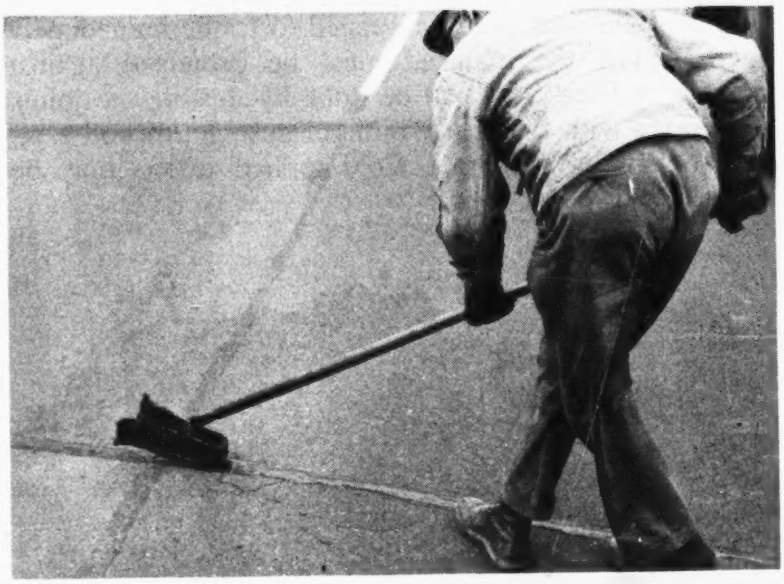

Figure III–1—Squeegee

is both convenient and rapid. It also avoids excessive spilling of the sealing material on the pavement surface.

Before any sealer is used joints and cracks must be cleaned out. Power routers, air compressors and sand blasters speed up and make the job much easier. The air compressor should be equipped with nozzles of the size and shape needed to direct the air stream into the crevice being sealed.

Just enough sealing material should be placed in the joint or crack to fill it. When hot sealer is used to fill deep crevices the material may shrink somewhat upon cooling. Enough additional sealer should be added to fill the opening flush with the surface. On airfield pavements used by jet planes, special sealing material should be used.

Frequently, pavements must be kept open to one-lane traffic while sealing work goes on. It is good practice for workmen to begin filling operations at the centerline and back towards the edge of the pavement. This will avoid backing into the stream of traffic.

If the pavement is to be opened to traffic immediately after sealing, the material must be protected against pick-up by tires. This can be done by dusting the joints and cracks with fine sand, mineral dust, hardwood sawdust, or similar materials. Cold-applied sealers may be covered with paper tape.

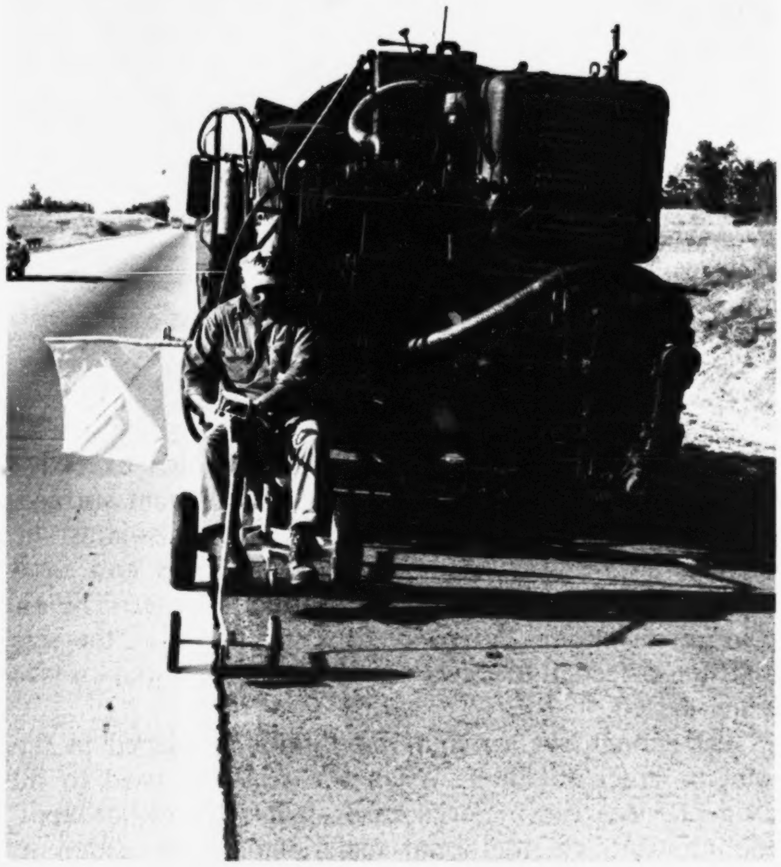

Figure III–2—Trailer-mounted seal applicator (*Photo courtesy Virginia Department of Highways*)

3.03 UNDERSEALING—Cavities may occur beneath a portland cement concrete pavement as a result of pumping of the slabs or settlement of the subgrade. When this happens they should be filled to restore the pavement's support and prevent further erosion. Undersealing asphalt is used for this purpose. It fills the cavities, raises sunken slabs, and forms a waterproof layer that prevents fine material from pumping out again. The process is called undersealing. It is fully described in The Asphalt Institute's publication *Specifications for Undersealing Portland Cement Concrete Pavements with Asphalt,* Specification Series No. 6 (SS-6).

CAUTION—Only asphalt especially prepared for undersealing should be used.

3.04 OVERLAYS—For many types of defect in portland cement concrete pavement an asphalt overlay is the most effective and most economical treatment. Distorted pavements often can be restored to smoothness with asphalt overlays. Disintegrating pavements can be salvaged and strengthened with them. Slippery pavements can be made skid resistant with the proper asphalt overlays. Generally, this type of correction is considered construction rather than maintenance. Overlays can be used for short stretches as a maintenance operation, however.

Overlays are discussed in The Asphalt Institute publications, *A Short, Practical Guide to the Design of Asphalt Overlays,* Information Series No. 139 (IS-139), and *Thickness Design—Asphalt Pavement Structures for Highways and Streets,* Manual Series No. 1 (MS-1).

A. Joints and Cracks

3.05 GENERAL—Relatively large volume changes are produced in portland cement concrete by variations in temperature. Because of this all such pavements crack; it is a natural property of the material. To make the concrete crack in neat, straight lines pcc pavements have joints at frequent intervals.

Joints are either formed the full depth of the slab or grooved to a depth of one-sixth to one-quarter of its thickness. Full-depth joints are junctions between slabs to permit expansion, to control cracking, or to meet construction requirements. Grooved joints are formed or cut to force cracking along the weakened plane. Depending upon their function, they are called expansion joints, contraction joints, or construction joints. They may run in a transverse, longitudinal, or diagonal direction.

Another type of joint is the one between the pcc slab and the shoulder. It is a longitudinal construction joint called a shoulder joint. See Figure III-3. Also, there are other types of joints which have special purposes. They are maintained in the same way as the main types.

All joints and cracks must be kept sealed with some adhesive material to prevent damage to the pavement from water and foreign matter. Asphalt, with or without an additive such as rubber, is used almost universally as a joint and crack sealing material.

The methods used for sealing joints and cracks are essentially the same. Both consist of cleaning out the upper portion of the crevices and filling them with a sealing material. To be effective, the sealing material must stick to the sides of the opening. For this reason any material which will prevent a good bond must be cleaned out. If sand, gravel, dust, or other foreign matters have accumulated in the opening they must be removed. They may cause the edges to spall when the joint or crack closes under expansion of the slab in hot weather. Old sealing material which has become hardened should also be removed.

If the job is small, the clean-out operations may be performed by hand. Stiff-fiber or steel-bristle brooms and bars with chisel ends shaped to fit the joint opening are tools that can be used. For larger jobs, the work can be done more rapidly with power-driven rotary cutters, power pavement saws, air compressors, or similar equipment.

Special treatment may be necessary where the joint or crack is very narrow or has badly spalled edges. When such conditions are encountered, a recess to receive the sealing material may be grooved out with a power-driven pavement saw or rotary cutter.

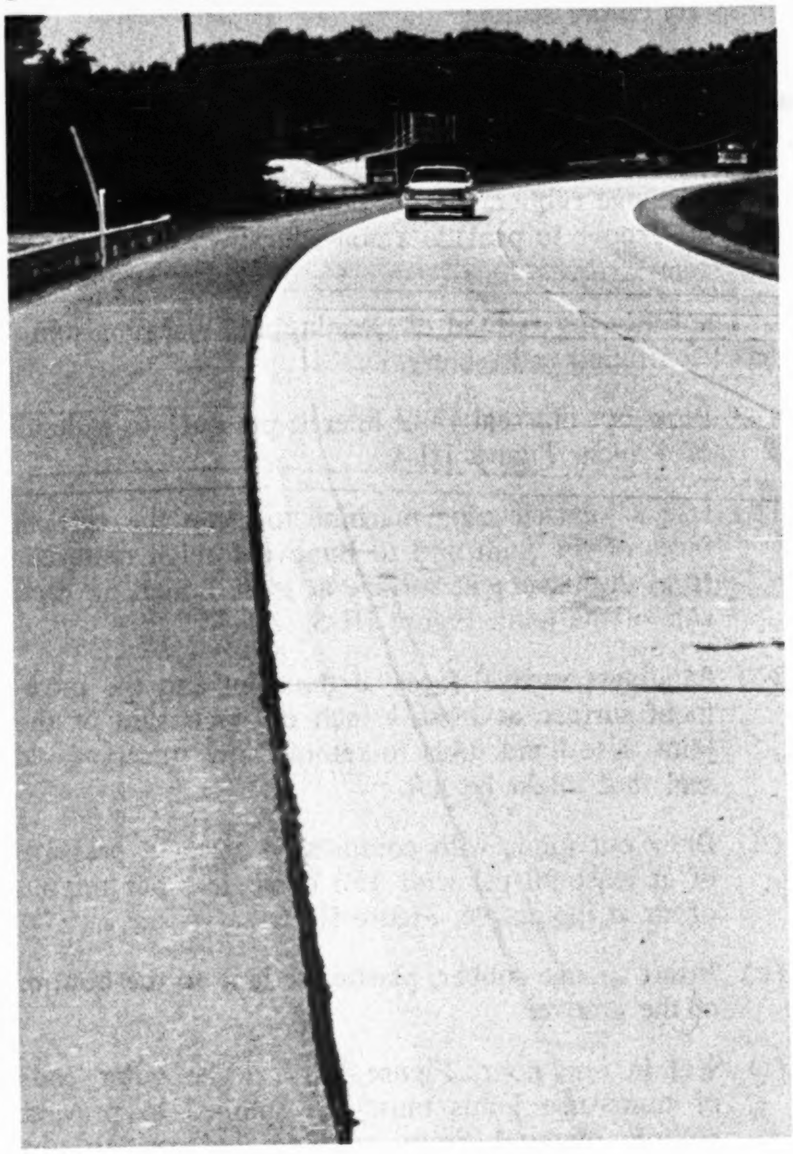

Figure III-3—Shoulder joint

3.06 RESEALING JOINTS—Joints need periodic maintenance. The joint seal may need replacing for any of a number of reasons, among them, the wrong type of material may have been used; the seal may have been overheated; the joint may not have been cleaned properly before sealing.

In all cases, joints needing resealing should be plowed out to a depth of 1 inch. Before the new seal is applied all surfaces in and around the joints should be clean and dry, with no bits of filler or old seal clinging to the sides. Sponge rubber, plastic, or tape should be inserted into the groove to provide a non-adhesive lower face for the seal.

The following method of cleaning and resealing joints has been found satisfactory.

(a) Plow out old seal (and filler if present) to a depth of 1 inch, Figure III-4.

(b) Use a joint-cleaning machine to clean the vertical faces of the joint and to remove foreign materials from the pavement surface at least 1 inch on each side of the joint, Figure III-5.

(c) Sandblast vertical faces of the joint and the pavement surface at least 1 inch on each side of the joint. Use hand tools to remove any traces of old seal that might be left.

(d) Blow out joints with compressed air at a pressure of at least 90 psi with 150 cubic feet per minute of air at the nozzle, Figure III-6.

(e) Insert sponge rubber, plastic, or tape to the bottom of the groove.

(f) Seal in one pour, Figure III-7. (The outer ends of transverse joints must be dammed to prevent sealing material from running out on to the shoulder.)

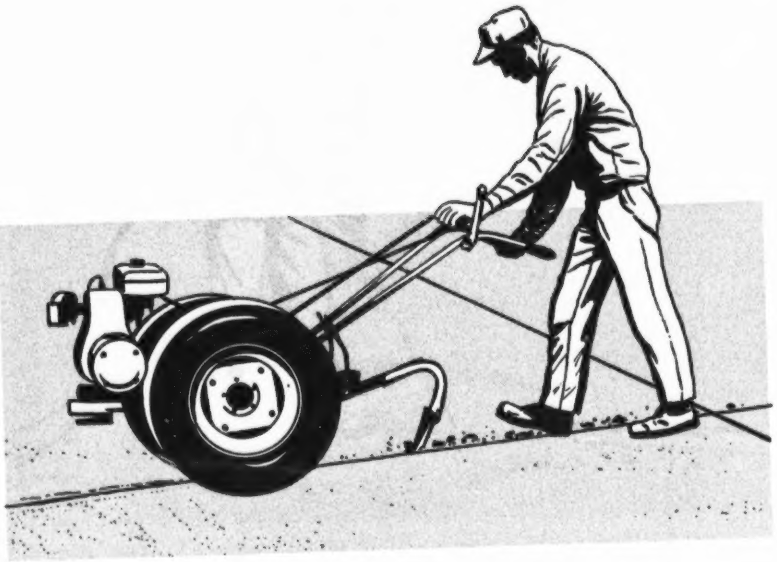

Figure III–4—Plowing out old seal

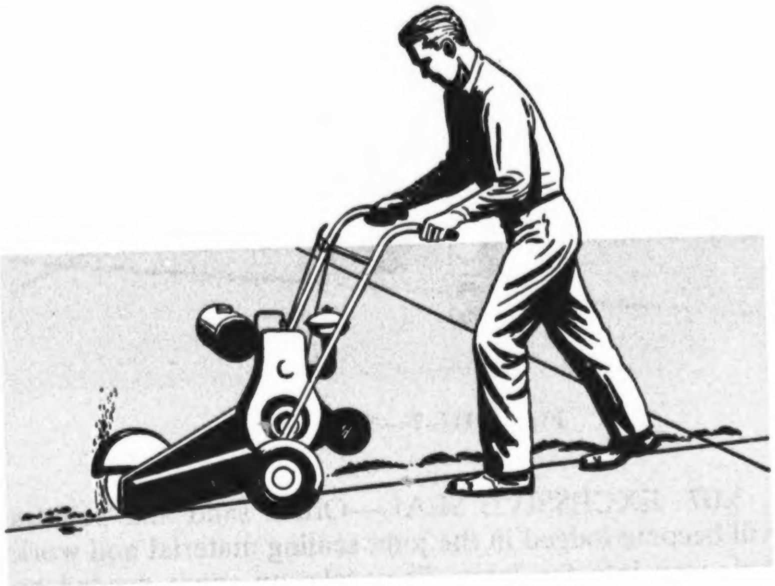

Figure III–5—Cleaning with joint-cleaning machine

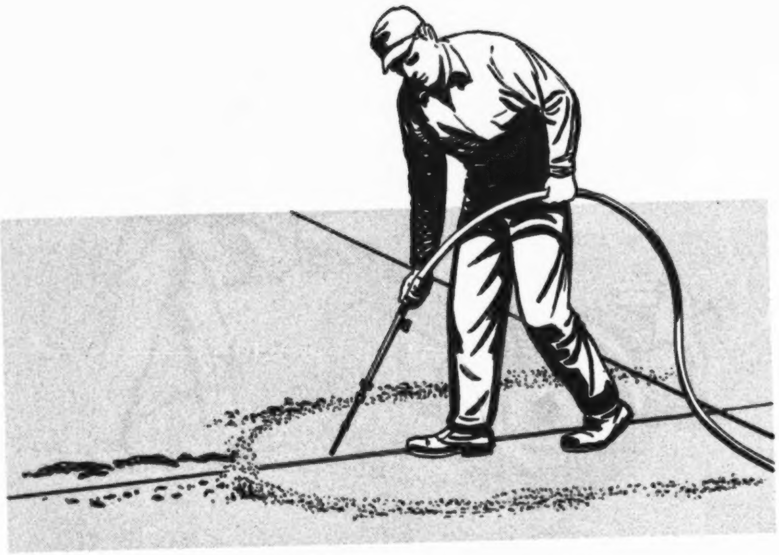

Figure III-6—Blowing out joints

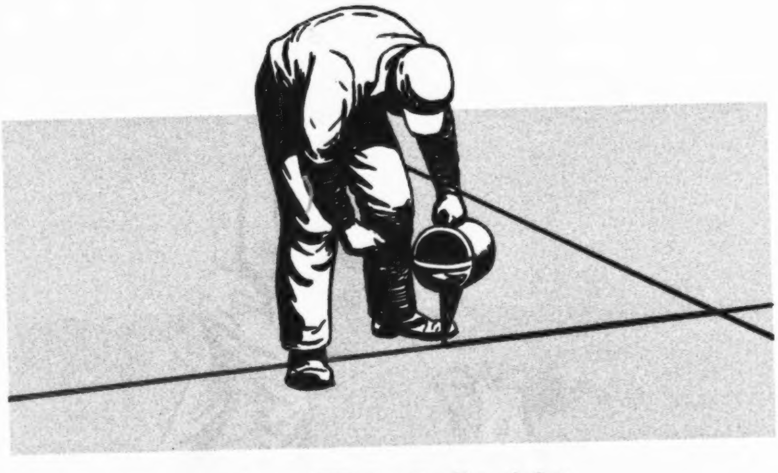

Figure III-7—Sealing joint

3.07 EXCESSIVE SEAL—Often, sand and pebbles will become lodged in the joint sealing material and work their way into the joint. They take up space needed by the sealing material and when the slabs expand the seal pushes up from the joint and forms a bump. Sometimes there is enough of this foreign matter in the joint to cause spalling of the slabs. When this happens the seal should be plowed out and the joint resealed (see *Resealing Joints,* above). But in many cases the excess can be removed by cutting it off with a heated square-point spade or a power-driven rotary cutter. When a large amount of extruded sealing material is to be trimmed, a special blade with plow handles, pulled by a truck or a winch may do the job effectively.

3.08 SEALING CRACKS—Cracks in portland cement concrete pavements are defined as "approximately vertical random cleavage due to natural causes or traffic action." Included under this definition are transverse cracks, longitudinal cracks, diagonal cracks, corner cracks, and restraint cracks.

If a crack is not wide enough to receive the sealing material with ease, sealing it should not even be tried. Wide cracks should be thoroughly cleaned before sealing.

3.09 CORNER CRACKS — These are diagonal cracks forming a triangle with a longitudinal edge or joint and a transverse joint or crack, Figure III-8.

(1) *Cause*—Corner cracks can be caused by traffic loads on unsupported corners or curled or warped slabs. They may also be caused by loads over weak spots in the subgrade under the slabs.

(2) *Repair*—Remove the broken corner and patch with dense-graded asphalt concrete.

(a) Remove the broken corner.

(b) Level the subbase, if required, and prime it as detailed in Specification P-1, Asphalt Priming of Granular Type Base Courses, *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13), The Asphalt Institute.

(c) Apply a tack coat to the sides of the slab.

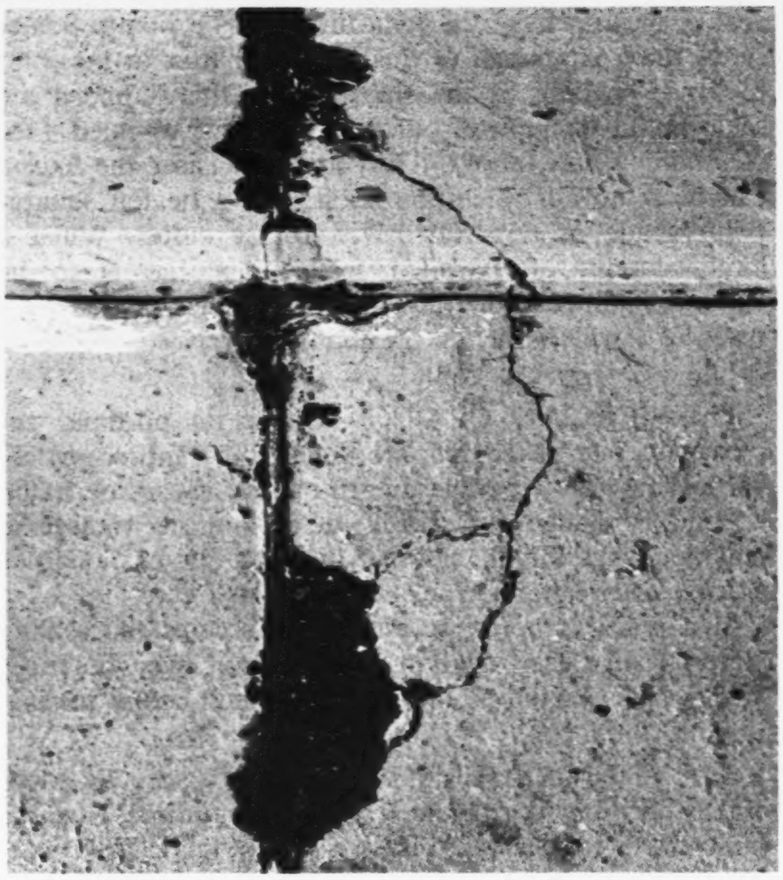

Figure III-8—Corner crack

(d) Place, in layers not exceeding 4 inches each in thickness, dense-graded asphalt concrete (Asphalt Institute Mix Type IVb).

(e) Compact with a vibrating plate compactor.

(f) The surface should be finished flush with the surrounding pavement.

3.10 DIAGONAL CRACKS—These cracks are diagonal to the centerline of the pavement, Figure III-9.

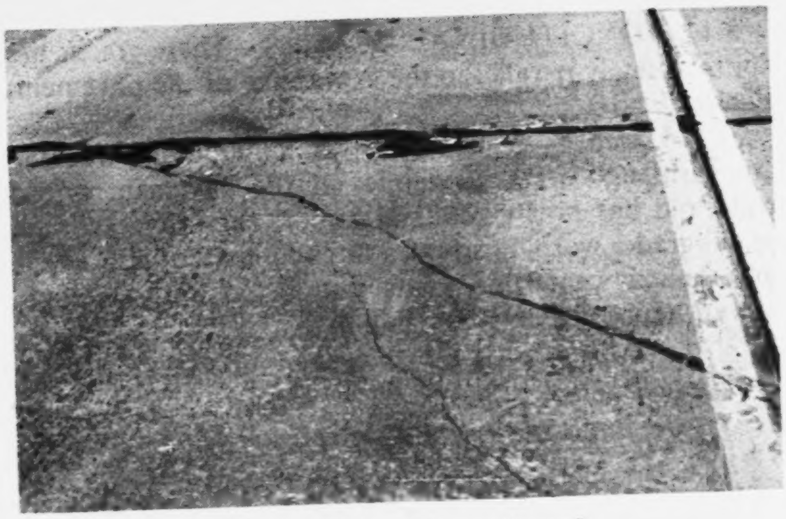

Figure III-9—Diagonal crack

(1) *Cause*—Diagonal cracks generally are caused by traffic loads on unsupported slab ends. The foundation settles or the slab curls, then subgrade soil pumps out, mostly along the edge. This results in a diagonal crack.

(2) *Repair*—Repair for this type of crack consists of filling the void beneath the pavement and cleaning and sealing the crack.

(a) Sandblast the vertical faces of the crack to a depth of at least 1 inch and the pavement surface at least 1 inch to each side of the crack.
(b) Blow out the crack with compressed air.
(c) Half fill the crack with a rubber-asphalt compound selected from Table III-1.
(d) Underseal the slab using the procedure detailed in *Specifications for Undersealing Portland Cement Concrete Pavements with Asphalt,* Specification Series No. 6 (SS-6), The Asphalt Institute.
(e) Finish filling the crack with the rubber-asphalt compound.

3.11 LONGITUDINAL CRACKS—These cracks are approximately parallel to the center line of the pavement, Figure III-10.

(1) *Cause*—Some causes of longitudinal cracking are shrinkage of the concrete (if the pavement is too wide and has no longitudinal joint), expansive subbase or subgrade, warping stresses in combination with loads, too shallow centerline joints not sawed early enough, loss of support from edge pumping.

(2) *Repair*—See repair procedure for *Transverse Cracks* (Article 3.13).

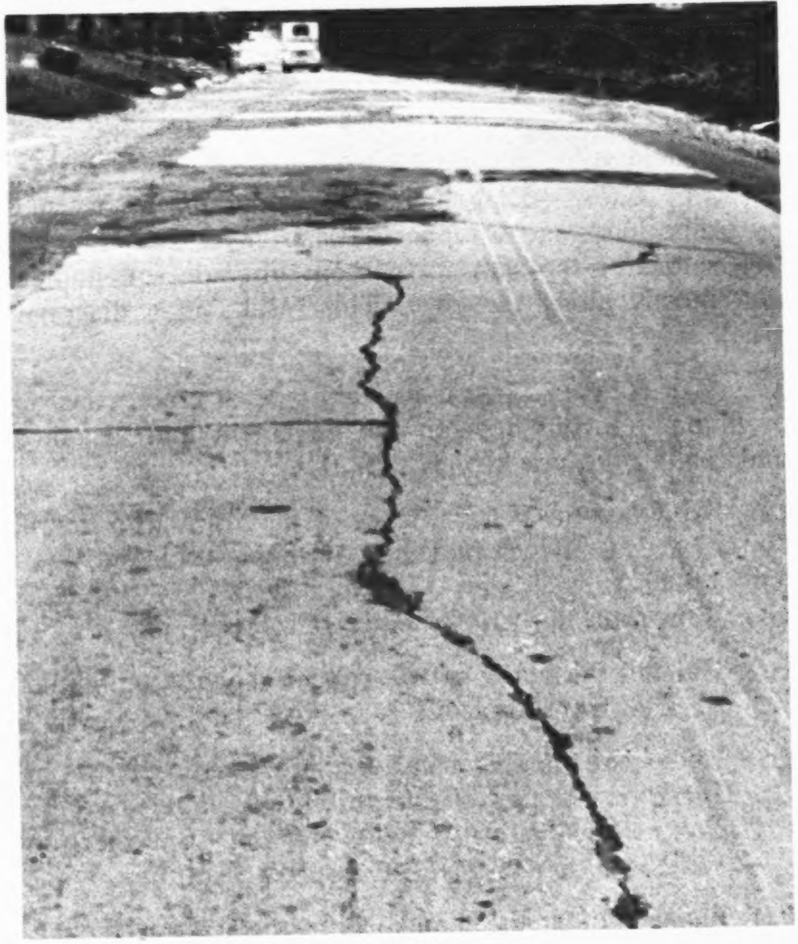

Figure III-10—Longitudinal crack

3.12 RESTRAINT CRACKS — These are cracks which develop near (within 3 feet or less) the outside edges of a pcc pavement and progress in an irregular path toward the longitudinal joint, Figure III-11.

(1) *Cause*—Restraint cracks are caused by foreign matter, such as hard gravel, becoming lodged deep in a transverse joint and restraining the slabs from expanding.

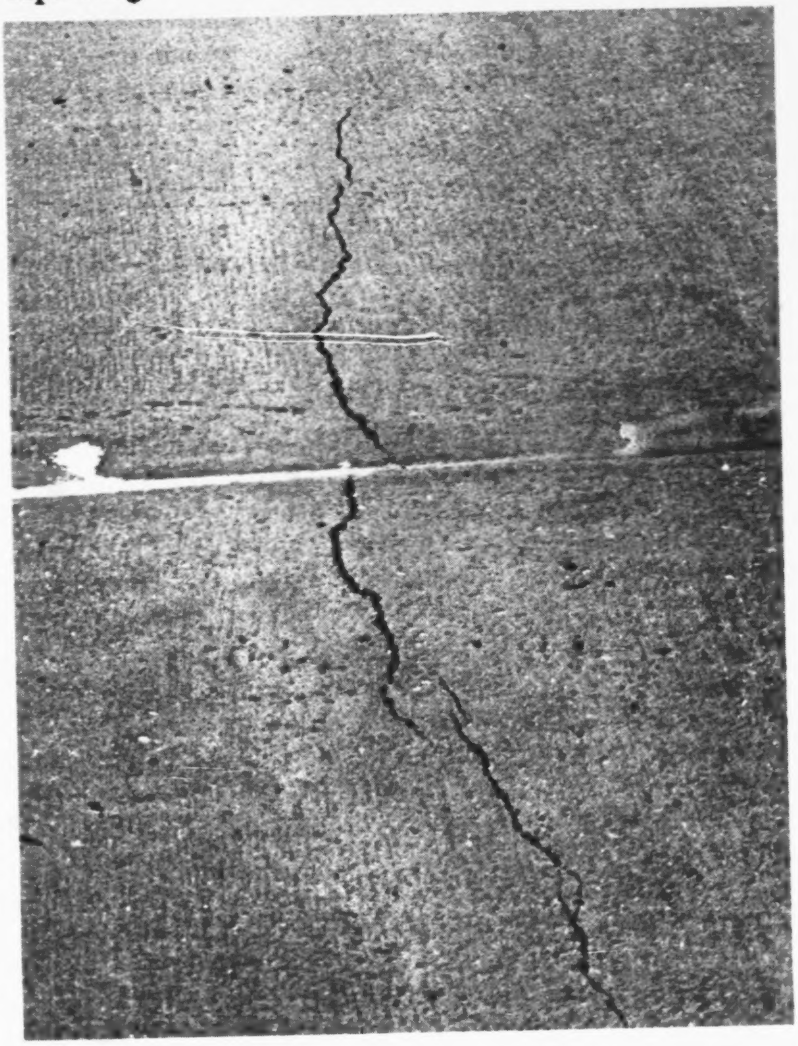

Figure III-11—Restraint crack

(2) *Repair*—The blocked transverse joint should be plowed out and resealed. The restraint cracks should be cleaned and sealed if they are wide enough to require sealing. The following references to cracks do not apply if the cracks are not to be sealed.

(a) Plow out the old sealer and foreign matter in the transverse joint to the depth required to remove all contamination.

(b) Use a joint-cleaning machine to clean the vertical faces of the joint and to remove foreign materials from the pavement surface at least 1 inch on each side of the joint.

(c) Sandblast the vertical faces of the joint and crack and the pavement surface at least 1 inch on each side of the joint and crack.

(d) Blow out the joint and cracks with compressed air at a pressure of at least 90 psi, with 150 cubic feet per minute of air at the nozzle.

(e) Seal the joint and cracks in two pours with a rubber-asphalt compound selected from Table III-1.

3.13 TRANSVERSE CRACKS — These cracks are approximately at right angles to the centerline of the pavement, Figure III-12.

(1) *Cause*—Some major causes of transverse cracks are overloads, repeated bending of pumping slabs, failure of soft foundations, "frozen" joints, lack of joints, too shallow joints, and shrinkage of the concrete.

(2) *Repair*—Clean the cracks of all loose matter and fill with a rubber asphalt sealer. If the crack is caused by pumping, the void beneath the pavement must be filled (see *Specifications for Undersealing Portland Cement Concrete Pavements with Asphalt,* Specification Series No. 6 (SS-6), The Asphalt Institute).

(a) Sandblast the vertical faces of the cracks to a depth of at least 1 inch and the pavement surface at least 1 inch to each side of the crack.

(b) Blow out the crack with compressed air.

(c) Fill the crack with a rubber-asphalt compound selected from Table III-1.

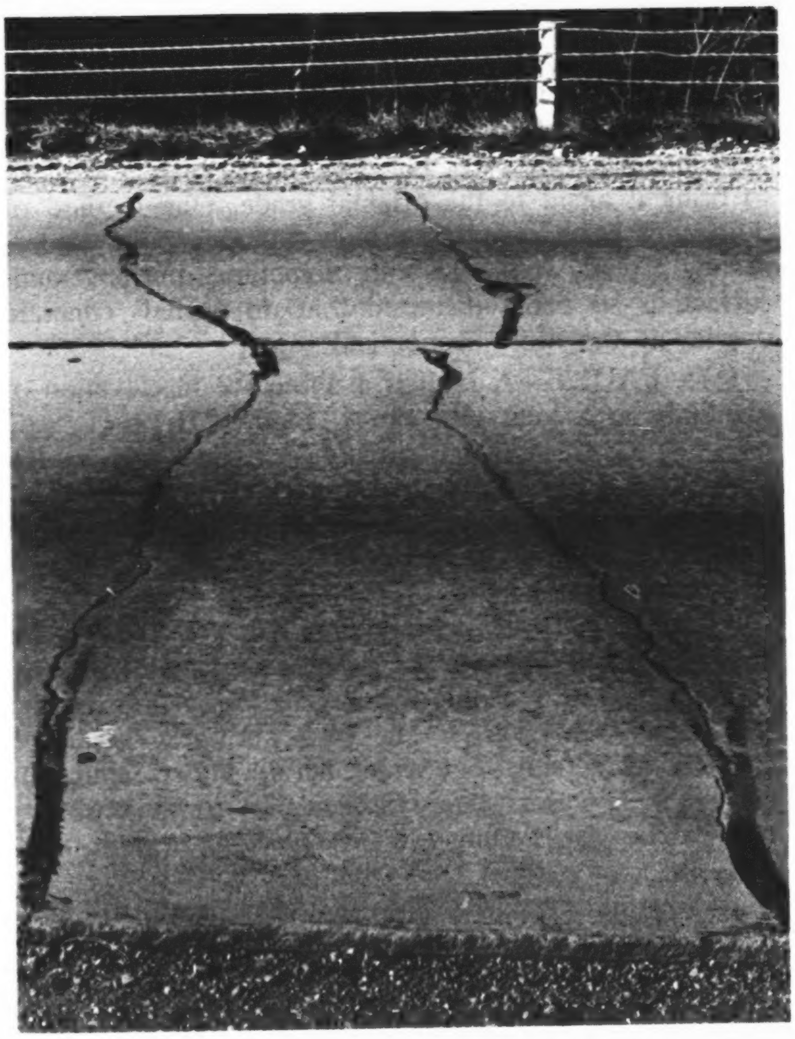

Figure III–12—Transverse cracks

B. Distortion

3.14 GENERAL—Distortion is any change of the pavement surface from its original shape. Faulting is one of the most predominant types of pcc pavement distortion. Pumping cannot be classified as distortion but it results in faulting or sunken slabs. Therefore, it is included in this section. Major causes of distortion are expansive soils, frost susceptible soils, and foundation settlement.

If not too extensive, some forms of distortion (such as from settlement) can be remedied by raising the slab to bring it again to the original grade. One method of doing this is by pumping a high softening point undersealing asphalt under the slab. Sometimes the pavement surface is so badly distorted that an asphalt concrete overlay is the most economical repair.

3.15 FAULT—A fault is a difference in elevation of two slabs at a joint or a crack, Figure III-13.

(1) *Cause*—Faults usually develop from inadequate load transfer between slabs along with consolidation or shrinkage in volume of courses underlying the slabs. They may be caused also by pumping out of the foundation material.

(2) *Repair*—If possible, faulted slabs should be brought back to the original grade with a high softening point undersealing asphalt cement underseal, raising the low side in the process. The joint or crack should be partially filled with joint sealer before undersealing begins. In some cases, it may be necessary to place wedge-type patches for leveling and then place an asphalt overlay.

(a) Plow out old sealer, if present, to a depth of 1 inch.
(b) If needed, use a joint cleaning machine to clean the vertical faces of the joint or crack and to remove foreign materials from the pavement surface at least 1 inch on each side of the joint or crack.
(c) Sandblast vertical faces of the joint or crack and the pavement surface at least 1 inch on each side of the joint or crack. Use hand tools to remove any traces of old sealer that might be left.
(d) Blow out the joint or crack with compressed air at a pressure of at least 90 psi, with 150 cubic feet per minute of air at the nozzle.
(e) Half-fill the joint or crack with a rubber-asphalt compound selected from Table III-1.

(f) Raise the slab to the original grade with a high softening point undersealing asphalt cement using the procedure detailed in *Undersealing Portland Cement Concrete Pavements with Asphalt,* Specification Series No. 6 (SS-6), The Asphalt Institute.

(g) Finish filling the joint or crack with the rubber-asphalt compound.

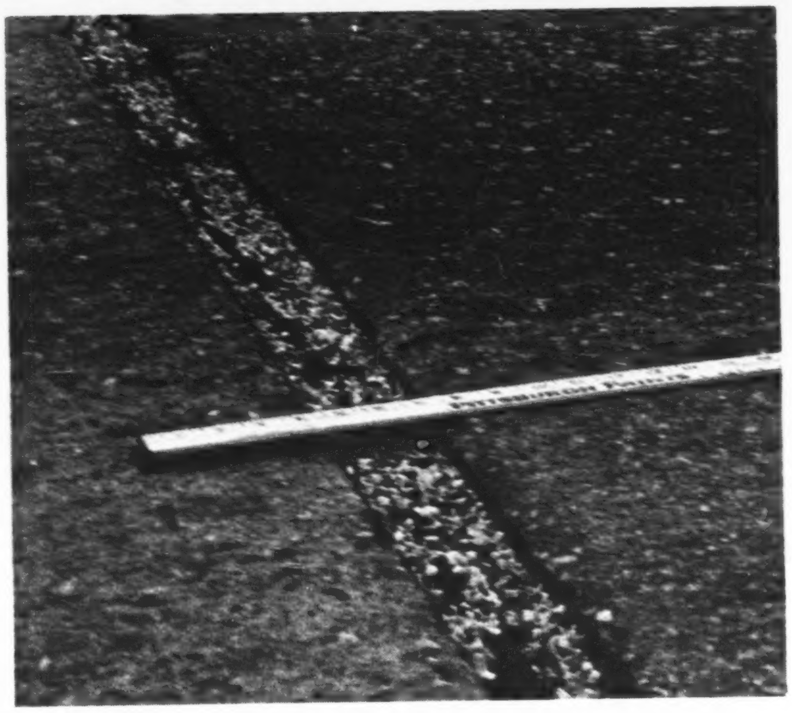

Figure III-13—Fault

3.16 PUMPING—Pumping is slab movement under passing loads resulting in the ejection of mixtures of water, sand, clay, and/or silt. Pumping can occur along transverse or longitudinal joints and cracks and along pavement edges, Figure III-14.

(1) *Cause*—Pumping out of fine material is caused by the presence of free water on or in the subgrade or subbase along with heavy loads passing over the pavement surface and deflecting the slab.

(2) *Repair* — The voids beneath the pavement should be filled with a high softening point undersealing asphalt. This will also waterproof the subgrade and subbase.

(a) Use the procedure for resealing joints detailed in Article 3.06, above.

(b) Use the procedure detailed in *Specifications for Undersealing Portland Cement Concrete Pavements with Asphalt,* Specification Series No. 6 (SS-6), The Asphalt Institute.

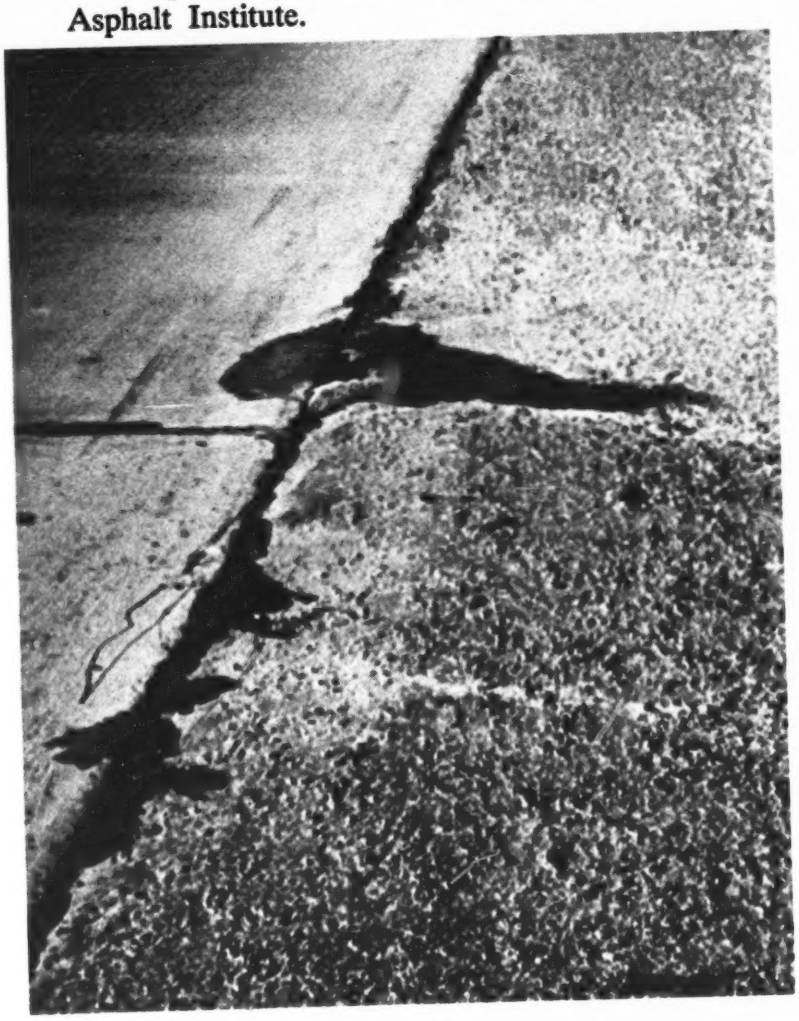

Figure III-14—Pumping

C. Disintegration

3.17 GENERAL—Disintegration is the breaking up of a pavement into small, loose fragments. This includes the dislodging of aggregate particles. If not stopped in its early stages, it can progress until the pavement requires complete rebuilding.

Common types of disintegration in portland cement concrete pavements that can be repaired with asphalt are blow-ups, spalling, and scaling. Treatment ranges from skin patches to complete overlays.

3.18 BLOW-UP—A blow-up is the localized buckling or shattering of a rigid type pavement, occurring usually at a transverse crack or joint, Figure III-15 and III-16.

(1) *Cause*—Most blow-ups are caused by excessive expansion of the slabs during hot weather. The pressure builds up until the slabs cannot resist it any longer and they either buckle or shatter, crumbling along the transverse joint or crack.

(2) *Repair*—Asphalt concrete may be used for emergency or permanent repair of the damaged slab. The slab should be cut, preferably with a power saw, to remove the affected area. Dense-graded asphalt concrete is then used to restore the pavement.

(a) Remove the damaged portion of the slab by sawing a straight, neat cut with a pavement saw.

(b) Level the subbase, if required, and prime it as detailed in Specification P-1, Asphalt Priming of Granular Type Base Courses, *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13), The Asphalt Institute.

(c) Apply tack coat to the sides of the slab.

(d) Place and compact dense-graded asphalt concrete (Asphalt Institute Mix Type IVb), in layers not exceeding 4 inches each. If the area is not large enough for a full sized roller, mechanical rammers and/or vibrating plate compactors should be used.

(e) The surface should be finished flush with the surrounding pavement.

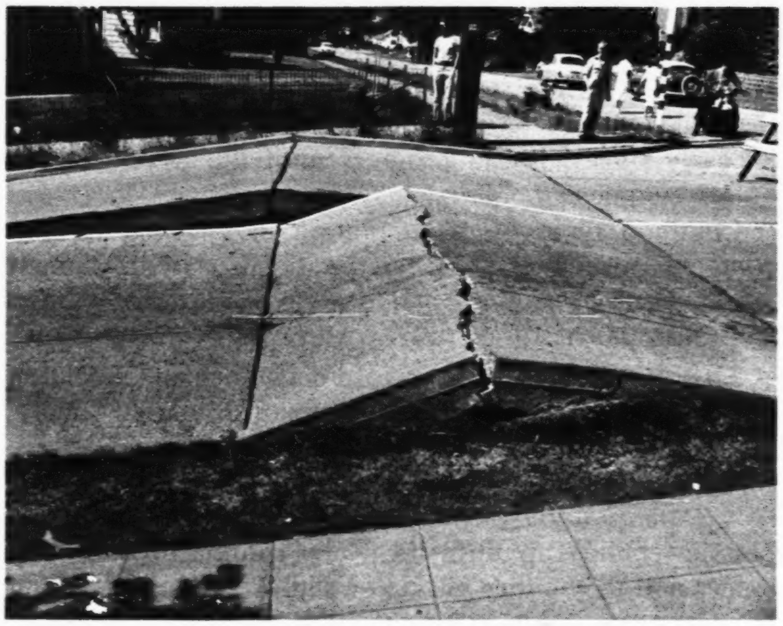

Figure III–15—Blow-up (buckling)

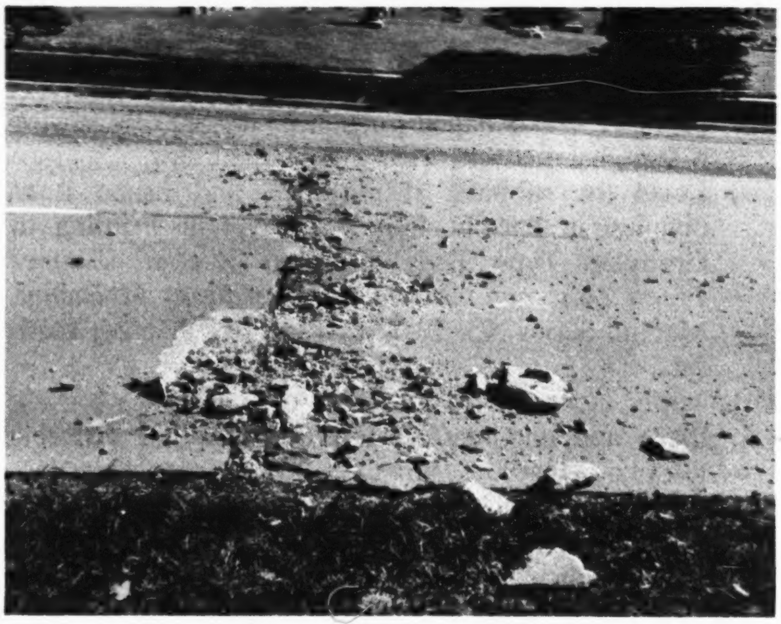

Figure III–16—Blow-up (shattering)

3.19 SCALING—Scaling is the peeling away of the surface of portland cement concrete, Figure III-17. In some cases the scaling can progress deeper and deeper into the pavement.

(1) *Cause*—Major causes of scaling are the chemical action of de-icing salts; overfinishing, improper mixing, unsuitable aggregates, and improper curing.

(2) *Repair*—If scaled areas are ⅜ inch or less in depth temporary repair may be made with asphalt emulsion slurry seal. If scaling is extensive and deep the pavement should be overlaid with asphalt concrete.

Temporary Repair:

(a) Remove all loose particles from the surface with a steel-bristle power broom.
(b) Clean the area with compressed air.
(c) Apply an asphalt-emulsion slurry seal to restore the surface to the original grade. *See* Specification ST-3, Asphalt-Emulsion Slurry Seal, *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13), The Asphalt Institute.

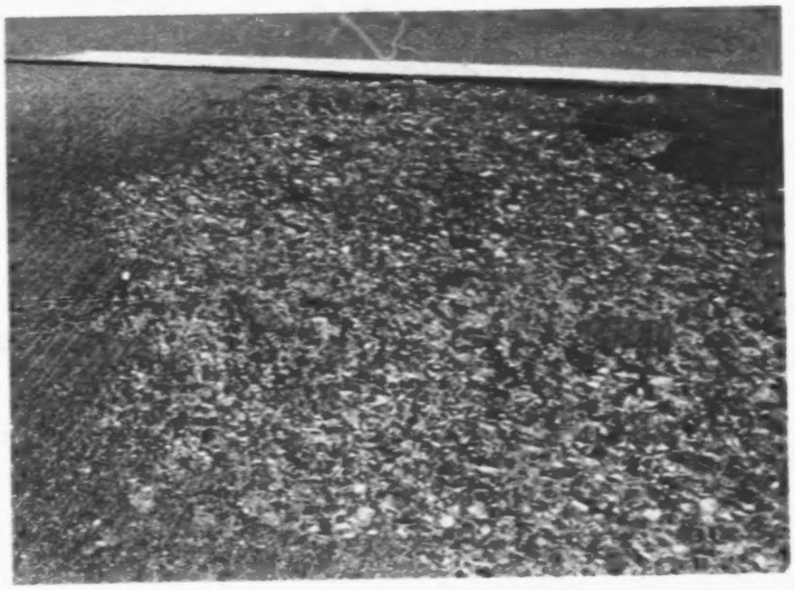

Figure III-17—Scaling

3.20 SPALLING—The breaking or chipping of the pavement at the joints, cracks, or edges is classified as spalling. Usually the resulting fragments have feather edges, Figure III-18.

(1) *Cause*—Spalling can be caused by a number of different things. Some of the major causes are hard pieces of gravel becoming lodged in a joint or crack; improperly installed load transfer devices; improper forming and sawing of joints; and weak mortar.

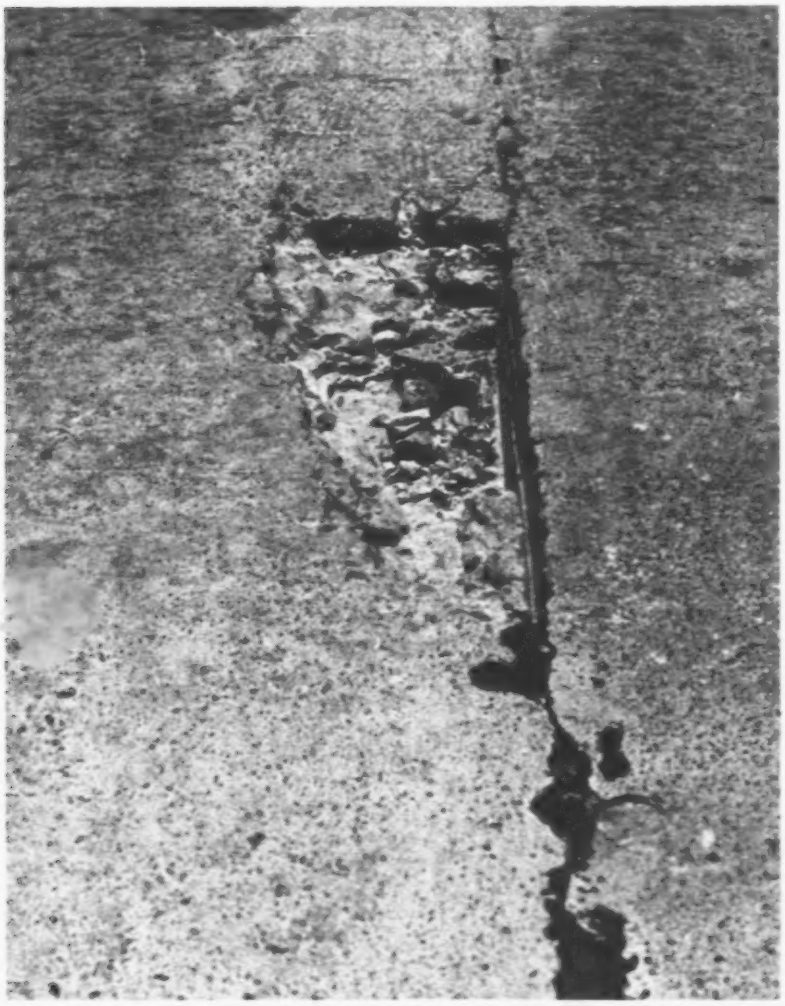

Figure III-18—Spalling

(2) *Repair*—Asphalt mixtures should be used for repair of spalling.

(a) Chip out the spalled area to sound material, squaring the edges and making the sides as nearly vertical as practical.

(b) Blow out the area with compressed air.

(c) Apply a light tack coat of SS-1 or SS-k asphalt emulsion.

(d) Fill the hole with a dense-graded asphalt concrete similar to Asphalt Institute Mix Type IVb. Place enough mix in the hole to ensure its being flush with the surrounding pavement after it is compacted.

(e) Compact with a vibrating plate compactor.

D. Skid Hazard

3.21 GENERAL—A number of things can make a pavement slippery when wet. A major cause of slippery portland cement concrete pavements is polished aggregates in the surface. The aggregate particles may be smooth, uncrushed gravel or they may be the type that polishes under traffic. Slipperiness also may develop from surface contamination. See discussion of slippery pavements, Article 2.26.

3.22 POLISHED AGGREGATE—These are aggregate particles in the surface of a pavement that have been polished smooth, Figure III-19. This includes both naturally smooth uncrushed gravels and crushed rock that wears down quickly under the action of traffic.

(1) *Cause*—Some aggregates will become polished quickly under traffic. Others, such as some types of gravel are naturally polished—if these are used in a pavement surface without crushing they will be a skid hazard. These polished aggregates are extremely slippery when wet.

(2) *Repair*—The most effective and economical way to repair a pavement with polished aggregates is to cover the surface with a skid resistant treatment. To reduce the probability of reflection cracking the overlay should be at least 3 inches thick.

(a) Apply a light tack coat (0.05 to 0.15 gallon per square yard of asphalt emulsion diluted with equal parts of water).
(b) Spread a course of asphalt plant mix using sharp, angular, non-polishing aggregate.
(c) Roll with rubber-tired and steel-wheeled rollers.

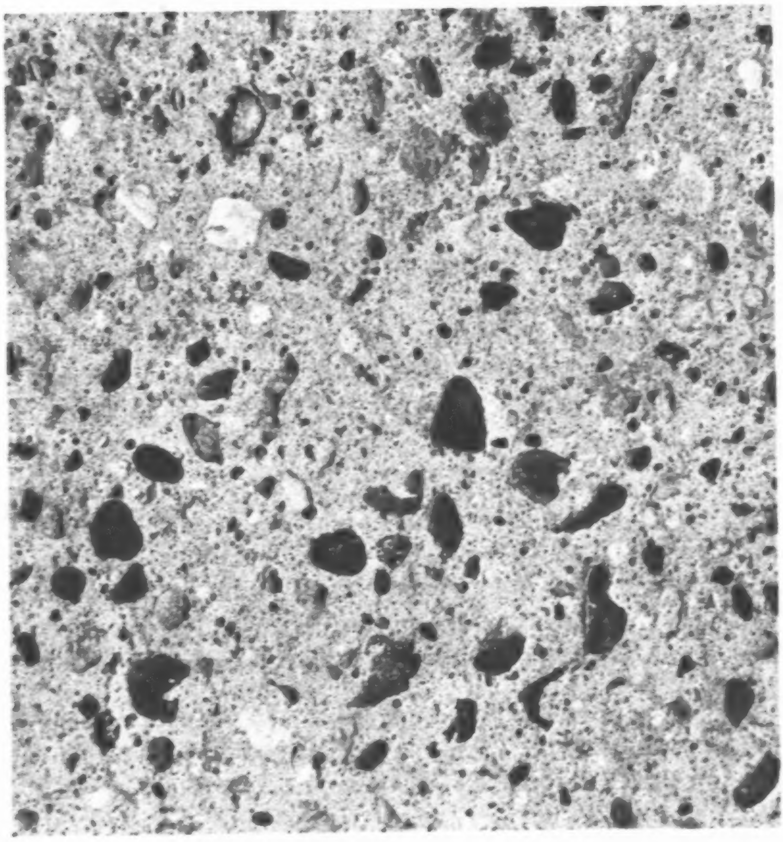

Figure III-19—Polished aggregate in pavement surface

Chapter IV

SELECTION OF ASPHALT AND ASPHALT MIXTURES

4.01 ASPHALT FOR MAINTENANCE — This chapter identifies the principal types of asphalt and asphalt mixtures used in maintenance work and the properties which are considered desirable in each case.

Asphalt is refined from crude oil and is a product of the petroleum industry. At ordinary temperatures, below approximately 100°F, it is solid or semi-solid. To be used in maintenance operations, then, it must be made liquid enough to coat the aggregate. This is accomplished in three different ways: (1) by heating, as in a heating kettle or storage tank; (2) by dissolving in a petroleum solvent (cutbacks); (3) by combination with water (emulsion). See Table IV-1 for the various grades recommended for use in pavement maintenance. For a more detailed treatment of asphalt and its uses, refer to *Introduction to Asphalt,* Manual Series No. 5 (MS-5), and *Specifications for Asphalt Cements and Liquid Asphalt,* Specification Series No. 2 (SS-2), The Asphalt Institute.

4.02 ASPHALT CEMENTS—Asphalt cement is the basic material of the asphalt family. It is a semisolid material that comes in five grades. They are used in making hot mixes, for penetration surface treatments and macadams, for seal coats, and for filling certain types of cracks. Asphalt cements are classified by a carefully-controlled test in which a standard size weighted needle penetrates a sample of asphalt at a specified temperature. The distance the needle penetrates into the asphalt in the specified time determines the grade. Thus, if at 77°F, the needle, under a weight of 100 grams, penetrates 90 tenths of a millimeter in 5 seconds, the asphalt

Table IV-1
RECOMMENDED USES OF ASPHALT IN PAVEMENT MAINTENANCE

TYPE OF CONSTRUCTION	References*	PAVING ASPHALTS				LIQUID ASPHALTS																							
						Rapid Curing (RC)				Medium Curing (MC)					Slow Curing (SC)				Emulsified										
																			Anionic					Cationic					
		60-70	85-100	120-150	200-300	70	250	800	3000	30	70	250	800	3000	70	250	800	3000	RS-1	RS-2	MS-2	SS-1	SS-1h	RS-2K	RS-3K	SM-K	CM-K	SS-K	SS-Kh
ASPHALT CONCRETE AND PLANT MIX, HOT LAID																													
Highways	SS-1	x	x	x										x				x											
Airports	MS-11	x	x																										
Parking Areas	MS-4	x	x																										
Driveways	MS-4	x	x																										
PLANT MIX, COLD LAID																													
Graded Aggregate	SS-1												x				x					x						x	x
ROAD MIX																													
Open-graded Aggregate	MS-14						x	x					x	x							x						x		
Dense-graded Aggregate	MS-14						x	x				x	x			x	x				x	x				x		x	
Clean Sand	MS-14						x	x				x	x										x					x	x
Sandy Soil	MS-14					x	x	x				x	x			x	x					x				x		x	x

PENETRATION MACADAM																													
Large Voids	MS-13		x					x	x											x					x				
Small Voids	MS-13			x			x												x					x					
SURFACE TREATMENTS																													
Single, Multiple and Aggregate Seal	MS-13			x	x		x	x	x			x	x	x					x	x		x		x	x			x	
Sand Seal	MS-13						x	x				x	x						x			x	x	x				x	x
Slurry Seal	MS-13																					x	x					x	x
Fog Seal	MS-13																					x[1]	x[1]					x[1]	x[1]
Prime Coat, open surfaces	MS-13						x					x																	
Prime Coat, tight surfaces	MS-13					x				x	x				x														
Tack Coat	MS-13					x													x			x[1]	x[1]	x				x[1]	x[1]
Dust Laying	MS-13									x	x				x							x[1]						x[1]	
PATCHING MIX																													
Immediate Use	SS-1											x					x												
Stock Pile	SS-1											x	x			x	x									x	x		
CRACK FILLING	MS-4					x													x			x[2]	x[2]	x				x[2]	x[2]
EXPANSION JOINTS	MS-4	Blown asphalts, mineral-filled asphalt cements, and preformed joint compositions																											
UNDERSEALING PCC	SS-6	Blown asphalts																											

In northern areas where rate of curing is slower, a shift from MC to RC or from SC to MC may be desirable. For very warm climates, a shift to next heavier grade may be warranted.

[1] Diluted with water.

[2] Slurry mix.

* Publications of The Asphalt Institute where specifications or additional information may be found.

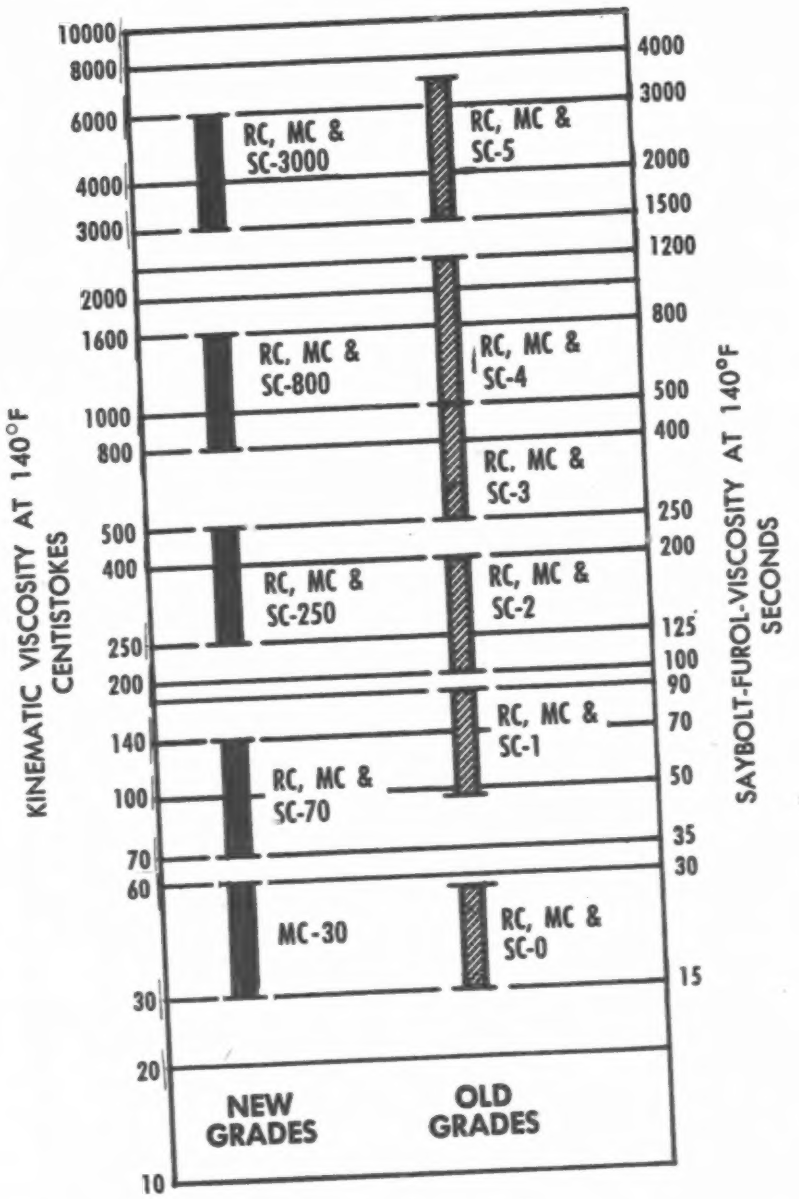

Figure IV–1—Comparison of new and old liquid asphalt grades at 140°F (60C)

is said to have a penetration of 90. Therefore, in Table IV-1, the 40-50 grade is the most viscous (hardest) and the 200-300 grade is the least viscous (softest). Moreover, it is necessary to heat the 40-50 grade to a higher temperature than the 200-300 grade to achieve the same viscosity (fluidity).

4.03 RC, MC, AND SC ASPHALTS—Asphalts which are liquified by blending with petroleum solvents are generally referred to as "cutbacks." When they are spread on the road or pavement, the solvent evaporates, leaving the asphalt cement behind. These liquid asphalts are made in two types according to curing time: (1) rapid-curing (RC), containing a naphtha-like solvent; (2) medium-curing (MC), with a solvent similar to kerosene. The slow-curing (SC) type usually is not called a cutback because its solvent, somewhat like heavy fuel oil, is not added but left in during the refining process. The SC type also is sometimes referred to as "road oil."

As shown in Table IV-1, each type is available in four viscosity-controlled grades ranging from Grade 70, which contains the most solvent and is the most fluid, to Grade 3000, which contains the least solvent and is the least fluid (slowest pouring). A special grade (MC-30) is included in the medium-curing type and is used almost exclusively for prime coating and dust laying.

4.04 ASPHALT EMULSIONS—Asphalt emulsions are liquid mixtures that contain asphalt cement, water, and an emulsifying agent. There are two general types, regular and inverted. In the regular type, minute globules of asphalt are suspended in water.

Asphalt emulsions are graded according to the time it takes for them to "break" or come out of suspension, and are referred to as rapid-setting (RS), medium-setting (MS), and slow-setting (SS). They usually have a dark brown color when the asphalt is in suspension and become black when the asphalt and water separate.

Regular asphalt emulsions come in two types: anionic and cationic. In the anionic type, the globules of asphalt have a negative electrical charge. In the cationic type, the globules are positively charged. These differences in electrical charge improve the coating and bonding properties of the emulsion when used with aggregates having oppositely charged surfaces.

Table IV-1 shows the grades which are commonly available. As in the cutback grades, the lower numbered grades are the most fluid, i.e., Grade 1 is more fluid than Grade 2. The small letter *h* in Grade SS-1h indicates that the base asphalt is a somewhat harder grade. The letter *K* indicates a cationic emulsion. The letters *SM* and *CM* refer to sand mixing and coarse aggregate mixing grades, respectively.

In the inverted type, minute globules of water are suspended in liquid asphalt, usually an RC.

4.05 PRIME COATS—Priming is the spraying of asphalt on to the surface of a non-asphalt base course for the following purposes:

To waterproof the surface of the base.
To plug capillary voids.
To coat and bond loose mineral particles.
To harden or toughen the surface.
To promote adhesion between the base and the surface treatment.

Priming should be done in accordance with Specification P-1, Asphalt Priming of Granular Type Base Courses, Appendix D, *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13), The Asphalt Institute. Briefly, this is the operation:

From 0.2 to 0.5 gallon per square yard of low viscosity liquid asphalt is sprayed on the prepared surface of the base and allowed to penetrate as far as possible. If the asphalt is not entirely absorbed by the base within 24 hours, the excess should be blotted with just enough sand to prevent pickup under traffic. Before beginning the next course all of the asphalt prime volatiles must have evaporated and all loose sand should be swept from the base.

The lower viscosity of the 30 and 70 grade liquid asphalts makes them better adapted for use on fine-grained, dense bases. The higher viscosity of the 250 grade liquid asphalt is desirable for open-textured, porous bases.

4.06 TACK COATS—As its name implies, the purpose of a tack coat is to provide a bond between an existing pavement and a course which is to be placed over it. None of the material is expected to penetrate into the pavement. and for this reason the application should be limited.

Because they can be diluted safely with clean fresh water asphalt emulsions SS-1, SS-1h, SS-K, and SS-Kh are much used for tack coats. The emulsion is thinned with an equal amount of water. Then the tack coat is applied at the rate of 0.05 to 0.15 gallon per square yard of diluted asphalt emulsion.

Liquid asphalts RC-70 and RS-1 also are sometimes used for tack coating.

The use of pneumatic-tired rollers on a freshly applied, *non-uniform* tack coat will aid in obtaining uniformity of coverage. It will also minimize the possibility of localized areas of excess tack which may later become a slip plane or cause "fat spots" in the pavement.

After application of the tack coat sufficient time should be allowed for complete separation of asphalt and water (if emulsion is used) or evaporation of solvent (if rapid curing liquid asphalt is used) before patching material or overlay is placed. Traffic should be kept off the tacked area when possible. When traffic is allowed, speed should be controlled to 25 mph or less.

4.07 SEAL COATS*—A seal coat is a thin surface-treatment. Usually it is a single application of an asphalt material which may or may not be covered or combined with aggregate. The principal types and uses of seal coats in pavement maintenance are described below.

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* For a complete discussion of seal coats refer to *Asphalt Surface Treatments and Asphalt Penetration Macadam*, Manual Series No. 13 (MS-13), The Asphalt Institute.

(1) *Fog Seal*—This is a light application of liquid asphalt, usually without aggregate cover. The main purposes of a fog seal are to:

A. Reduce entrance of air and water into the pavement.
B. Prevent raveling of a pavement laid in the late fall.
C. Restore or rejuvenate the surface of the pavement.

Slow-setting asphalt emulsions SS-1, SS-1h, SS-K, and SS-Kh, diluted with clean water, generally are used for fog seals. The emulsion is diluted with an equal amount of water and sprayed at the rate of 0.1 to 0.2 gallon (of diluted material) per square yard, depending on the texture and dryness of the old pavement.

(2) *Slurry Seals*—Slurry seals are mixtures of slow-setting asphalt emulsions, fine aggregate, mineral filler, and water. They may be mixed in a conventional plaster mixer, in concrete transit mixers, in special machines designed for the purpose, or in a wheelbarrow if the quantities are small. The mixture is prepared in the form of a slurry and is applied in an average thickness of one-sixteenth to one-eighth inch.

The mixture should form a creamy-textured slurry which, when spread, will flow in a wave approximately two feet ahead of the strike-off squeegee. This will allow the slurry to flow down into the pits and cracks in the pavement and fill them before the strike-off passes over. If the mixture is too stiff it will have a tendency to pile up immediately in front of the squeegee and may bridge over the cracks instead of filling them. The following proportions, based on 100 pounds of aggregate, will serve as a guide in making a trial batch of slurry seal.

APPROXIMATE PROPORTIONS FOR SLURRY SEAL

Material	Weight, Pounds
Aggregate, including mineral filler	100
Asphalt emulsion*	15-30
Water**	10—15 (as required for proper consistency)

* The slow-setting asphalt emulsions SS-1, SS-1h, SS-K, and SS-Kh are preferred for slurry seals

** This includes the water present in the emulsion and in the aggregates.

TYPICAL AGGREGATE GRADATION FOR SLURRY SEAL†

U.S. Standard Sieve Size	Total Percent Passing
No. 8	100
No. 16	65—90
No. 30	40—60
No. 50	25—42
No. 100	15—30
No. 200	10—20

† National Slurry Seal Association Type I Slurry Seal Surface

Additional information on slurry seals may be found in *Asphalt Surface Treatments and Asphalt Penetration Macadam*, Manual Series No. 13, (MS-13), The Asphalt Institute.

(3) *Aggregate Seals and Sand Seals*—These consist of sprayed asphalts which are immediately covered with aggregate and rolled. The choice of asphalt depends to

some extent on the available equipment, the weather, and the experience of the maintenance crew. As shown in Table IV-1, the recommended types include the softer grades of paving asphalt and the heavier grades of liquid asphalt. Details on this type of seal coat are contained in *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13), The Asphalt Institute.

4.08 CRACK-FILLING MATERIALS — Small cracks, except hairline cracks, may be filled with any asphalt which can be made liquid enough to flow into the crack. When hot paving-grade asphalts are used, they tend to bridge over at the top and do not penetrate far into the crack.

The asphalt recommended for filling small cracks in asphalt pavements are the lighter grades of rapid- and medium-curing liquid asphalts (heated* if necessary to a pouring viscosity) and slurry seal.

For larger cracks the same asphalts may be combined with fine sand or other fine aggregate and broomed into the cracks. These larger cracks may then be sealed with asphalt and dusted with fine aggregate or mineral dust to prevent tracking. The materials for joint- and crack-sealing of portland cement concrete pavements are discussed in Chapter III.

4.09 PATCHING MATERIALS—The following paragraphs describe, in a general way, the most common types of asphalt mixtures used in maintenance operations. There are, of course, other mix compositions which have successful service histories in various localities. These should be used when they are available.

(1) *Asphalt Concrete* — This is a high quality, thoroughly controlled hot mixture of well-graded, high quality aggregate and asphalt cement. The materials are

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* Do not use a flame torch with cutback asphalts; they contain flammable solvents.

mixed at a high temperature and should be laid and compacted before the mix temperature drops much below 200°F. These mixtures are designed for strength and long life. When it is practical and economical to do so, preference should be given to their use. For complete details of these mixes, refer to *Specifications and Construction Methods for Asphalt Concrete and Other Plant Mix Types,* Specification Series No. 1 (SS-1), The Asphalt Institute.

(2) *Cold-Laid Paving Mixtures*—These are mixes which are mixed at a temperature adequate for proper drying of the aggregate surfaces and liquefaction of the asphalts. They may be laid immediately, if properly aerated, or they may be stockpiled for future use. They are made in a plant by mixing mineral aggregates with an asphalt cement, a liquefier, and hydrated lime. For details of this type mix refer to *Specifications and Construction Methods for Asphalt Concrete and Other Plant Mix Types,* Specification Series No. 1 (SS-1), The Asphalt Institute.

(3) *Plant Mixes with Liquid Asphalts, Cold Laid*—These mixtures consist of a local aggregate and a liquid asphalt mixed in a plant. They may be used immediately, if properly aerated, or stockpiled for future use. The mixtures may or may not be controlled with the same precision as required for asphalt concrete. The asphalt materials commonly used in these mixtures may be either a cutback asphalt or an asphalt emulsion. For details of these mixtures, refer to Appendix A.

(4) *Road Mixes with Liquid Asphalts*—These are mixtures, usually local mineral aggregates road mixed on a suitable mixing table, with either medium or slow-curing liquid asphalt. The mixtures normally are stockpiled for future use.

The aggregate should be at least surface dry. It should be heated if its temperature is less than 50°F. The mixture consisting of approximately 94 to 96 percent of aggregate and 4 to 6 percent of liquid asphalt may be mixed in a hot-mix plant, travel plant, or with road mixing equipment. The completed mixture should be stockpiled in a well-drained, accessible location. The stockpile should be carefully shaped to shed rainwater and prevent saturation of the mix.

For details on the design of stockpile patching mixtures refer to Appendix A.

Chapter V

THE CARE OF MAINTENANCE EQUIPMENT

5.01 INTRODUCTION—Proper care of equipment is one of the most important functions of the maintenance crew. Much of the equipment used for maintenance work is costly and complex. Lack of proper lubrication, minor adjustments, and other periodic servicings usually result in lost time, costly repairs, and premature replacements. Additionally, lack of equipment care frequently results in unsatisfactory work which may have to be repeated.

5.02 ASSIGNMENT OF RESPONSIBILITY—Most agencies assign the major responsibility for equipment care to the operator. This includes periodic inspection, lubrication, minor adjustments, cleaning, and similar routine chores. When an agency is large enough to maintain a repair shop for its equipment, the responsibility may be divided. But no matter where it is placed, there must be a clear understanding as to where it rests. Supervisors, on their part, should give the operators time to acquire the skill necessary for the operation of the equipment. They also should provide each operator with easily understood literature for proper care of his equipment.

5.03 ADVANTAGES OF OPERATOR RESPONSIBILITY—When the operator is responsible for the care of his equipment, he will be more likely to practice safe operation, avoid overspeeding, rough use, or other abuses. Moreover, if he has to keep the equipment clean, he will be more likely to take pride in his work.

5.04 ADVANTAGES OF REPAIR SHOP RESPONSIBILITY—When operators are switched from machine to machine for greater flexibility, it is a good plan to place the major responsibility for service and repair on a central shop. This will limit the operator's responsibilities to adjustments which can be quickly performed on the job. Better use can thus be made of a skilled operator's time and ability.

5.05 RECORDS OF SERVICINGS AND REPAIRS —Much of the work required for equipment care is of a periodic nature, such as lubrication, inspection of tires, batteries, antifreeze. It is important, therefore, that records be kept to show the dates on which these services were previously performed. Such a record should preferably be kept with or attached to the machine for easy reference when an inspection is made. The service record should show the date, the service performed, and any associated details such as mileage, accidents, and causes of damage.

5.06 CARE OF DISTRIBUTOR — The distributor operator should spend some time *each day* on necessary cleaning, greasing, and adjustments.

(1) At the start of the day's work apply heat to the pump and nozzles to remove any cold asphalt which interferes with their operation. Apply heat cautiously, particularly if the previously-used material was a cutback or if any flammable cleaning fluids were used on the distributor the previous day.

(2) At the end of the day's work blow out all lines thoroughly and clean the pump with kerosene or light oil. Clean off any asphalt which has collected on the distributor.

(3) Make a periodic inspection of the interior of the distributor tank to be sure there is no build-up of coke. These deposits may cause serious trouble since the coke particles break away and clog up the screen and nozzles. About the only way coke deposits can be removed is for someone, properly masked against fumes, to go inside the tank and scrape them off with a putty knife or similar instrument.

(4) Frequently check the distributor piping system for leaks. Any found should be repaired as soon as possible.

For a detailed discussion of the asphalt distributor see *Asphalt Surface Treatments and Asphalt Penetration Macadam,* Manual Series No. 13 (MS-13), The Asphalt Institute.

5.07 CARE OF HEATING KETTLE—The person in charge of heating kettle operations should inform all workmen of the dangers of heating asphalt materials in the presence of open flames. He should require regular inspection of the kettle, particularly looking for those features which may result in serious injuries.

(1) Before lighting the burner, aerate the fire box and flues to make sure all combustible fumes have been exhausted. Inspect the asphalt compartment to be certain it is free of water. Even a small amount of water may cause the asphalt to foam and overflow when it is heated. If RC liquid asphalt is being used, be extremely cautious. Keep a fire extinguisher at hand.

(2) Keep the level of the asphalt material well above the top of the heating flues at all times.

(3) Heating asphaltic materials to high temperatures damages the asphalt. It also may cause combustible fumes in the asphalt compartment that could result in an explosion.

(4) If the burner goes out, do not attempt to relight it immediately. Wait until the firebox and flues have been properly aired out.

(5) Inspect the burners and fuel lines regularly for leaks.

5.08 SMALL TOOLS—Small tools, such as rakes, shovels, and lutes, which come in contact with asphalt materials, should be cleaned at the end of each operation

with kerosene or a similar solvent. If the operation is continuous for a full day, these tools should be cleaned frequently during the day.

Chapter VI

SOME MAINTENANCE TOOLS

6.01 MAINTENANCE TOOLS—In this chapter are pictures of a few of the tools that ease the job of maintaining pavements. Several manufacturers may produce the same type of tool. Therefore, the following illustrations represent types rather than brands. The ones pictured were selected at random and do not imply endorsement of any particular make by The Asphalt Institute.

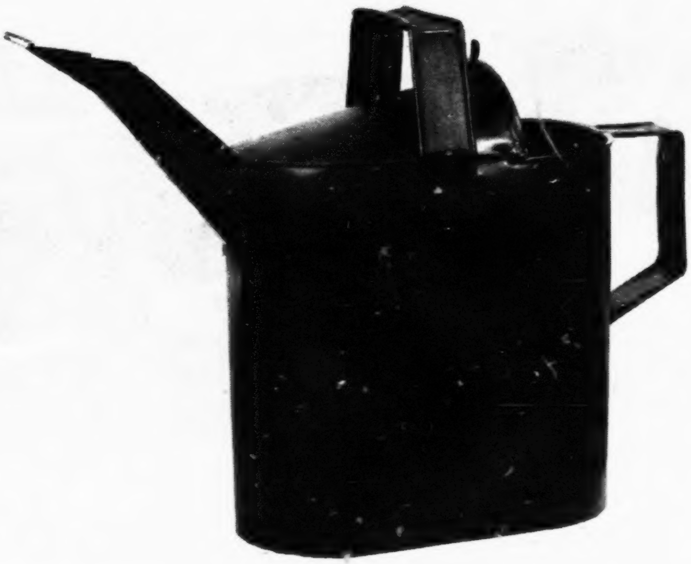


Figure VI-1—Asphalt pouring pot

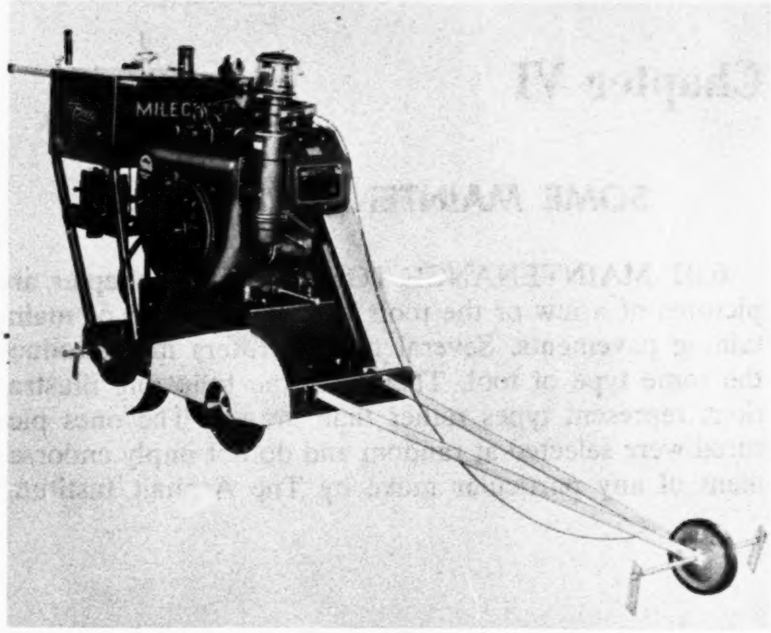


Figure VI–2—Pavement power saw

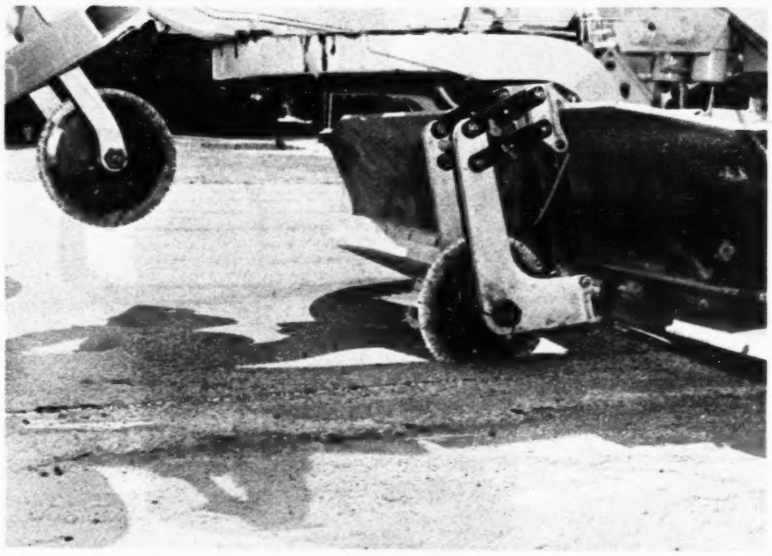
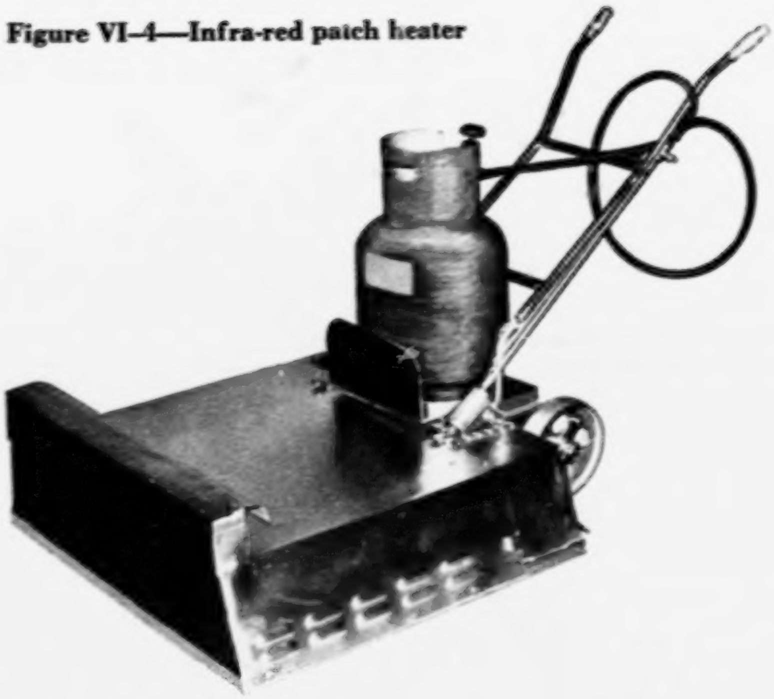


Figure VI–3—Pavement cutting disk mounted on motor grader blade

Figure VI-4—Infra-red patch heater



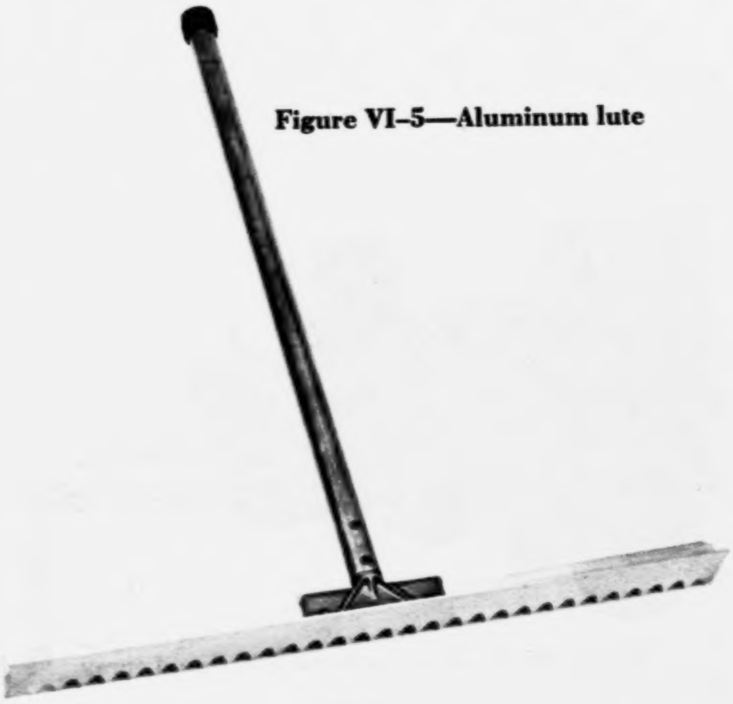


Figure VI-5—Aluminum lute

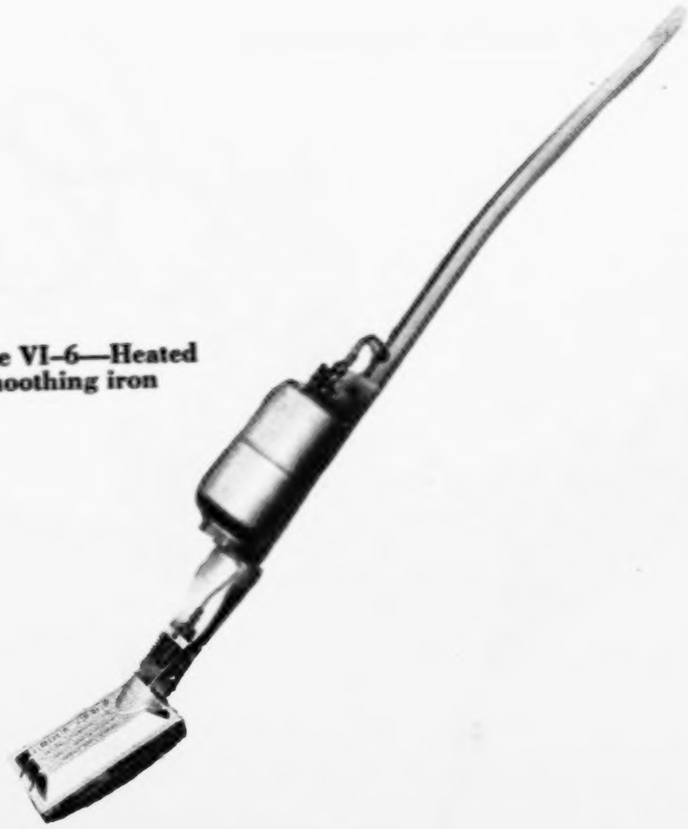


Figure VI-6—Heated smoothing iron

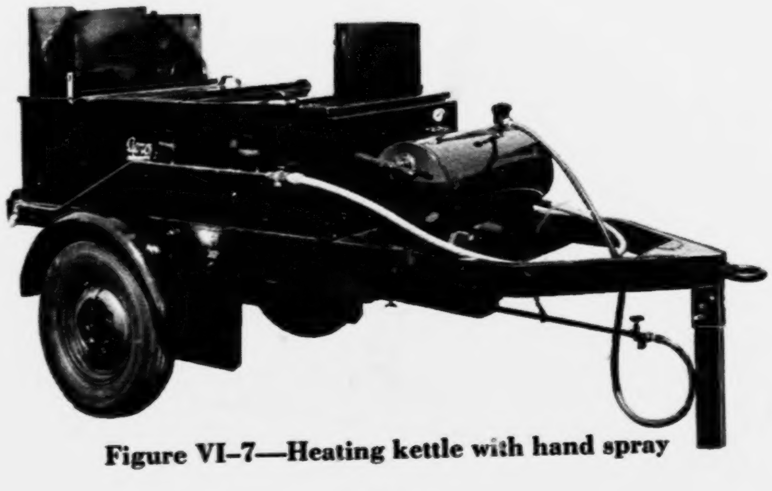


Figure VI-7—Heating kettle with hand spray

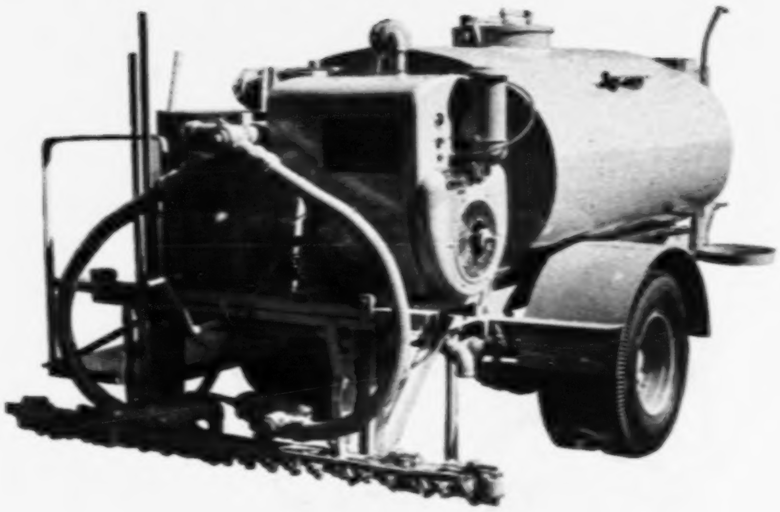


Figure VI-8—Maintenance asphalt pressure distributor

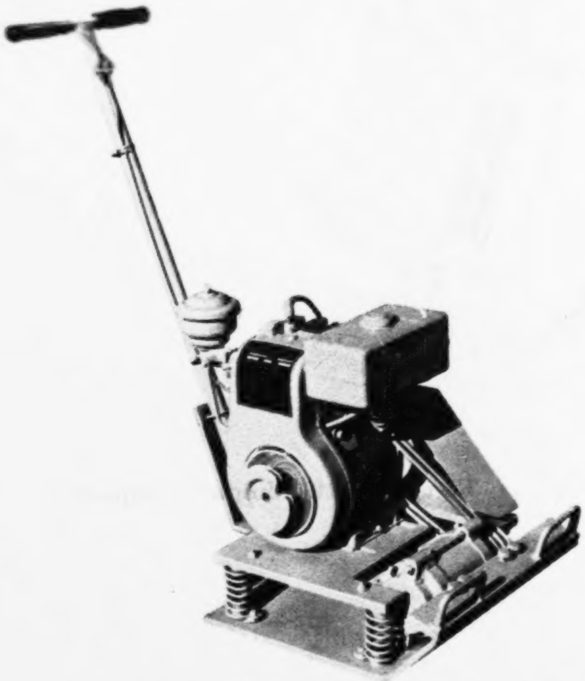


Figure VI-9—Vibratory plate compactor

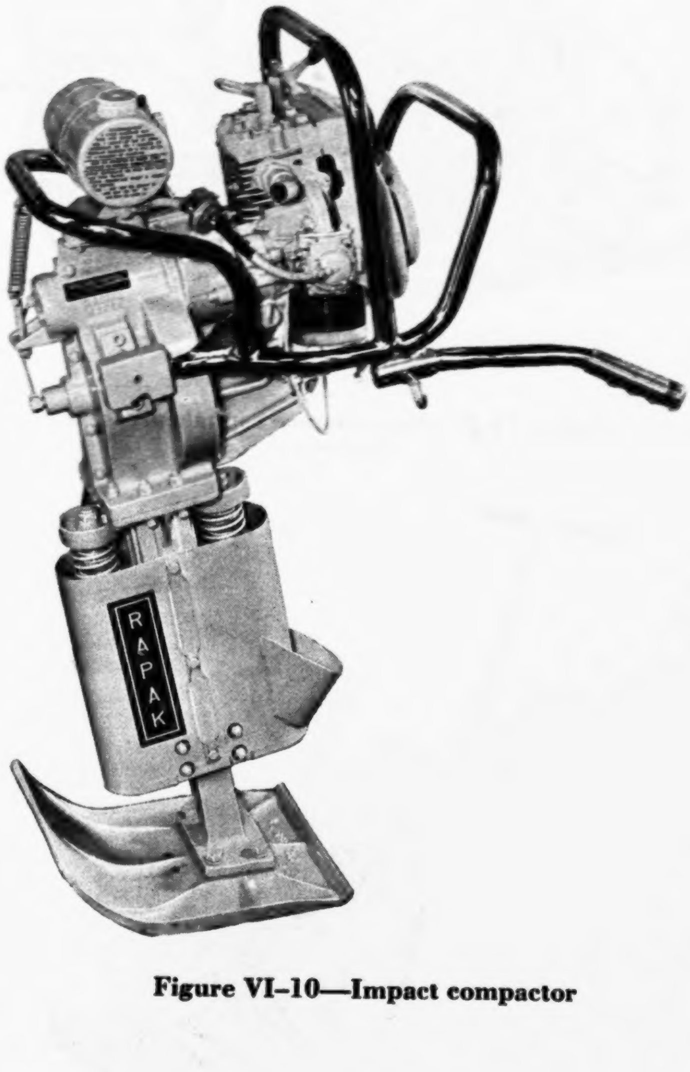


Figure VI-10—Impact compactor

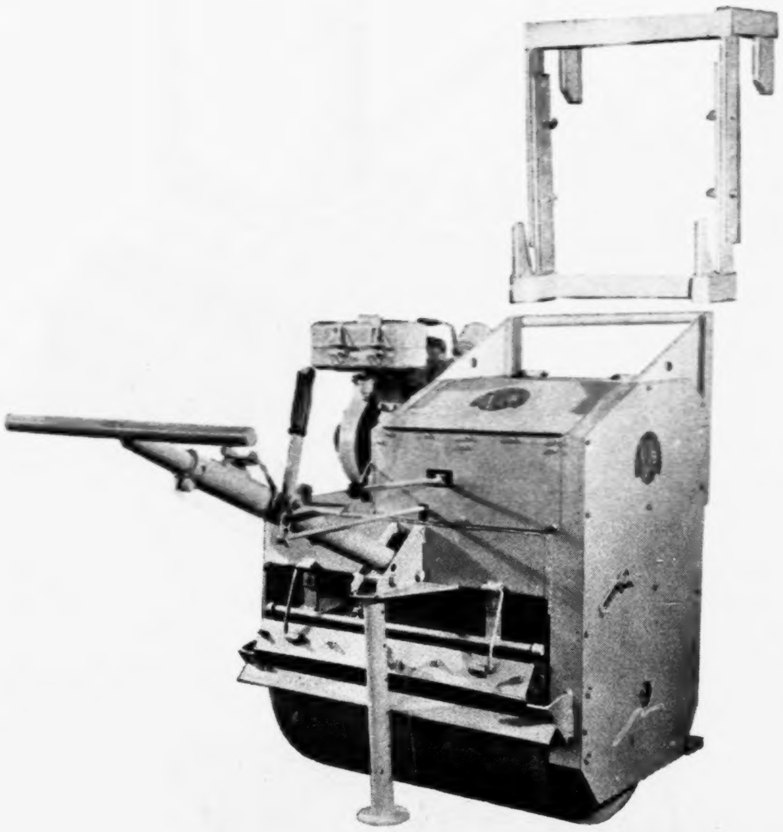


Figure VI-11—Vibratory roller

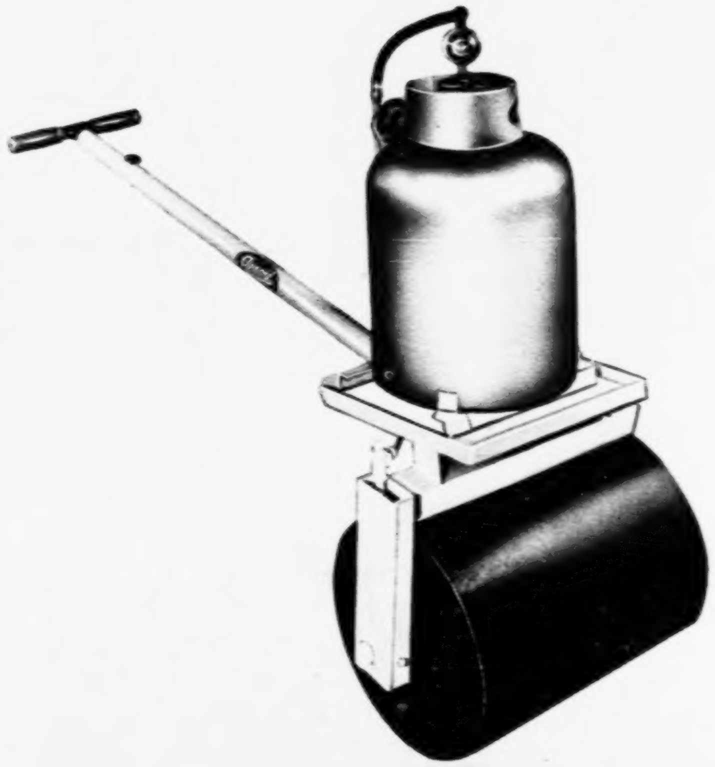


Figure VI-12—Hot roller

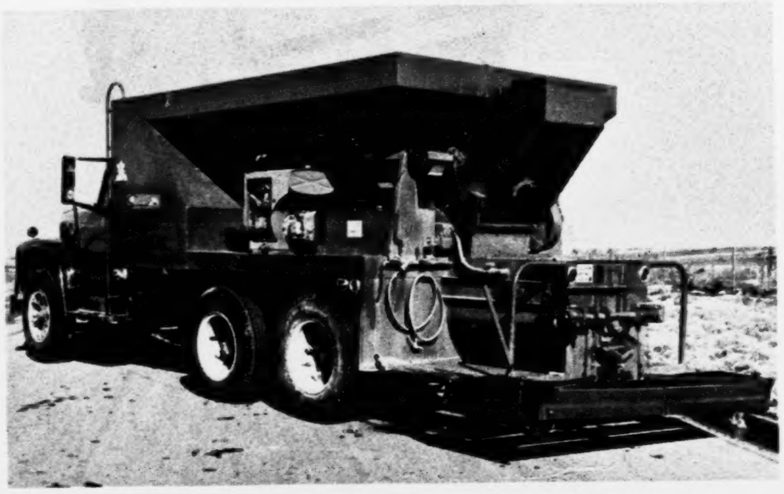


Figure VI-13—Slurry-seal machine

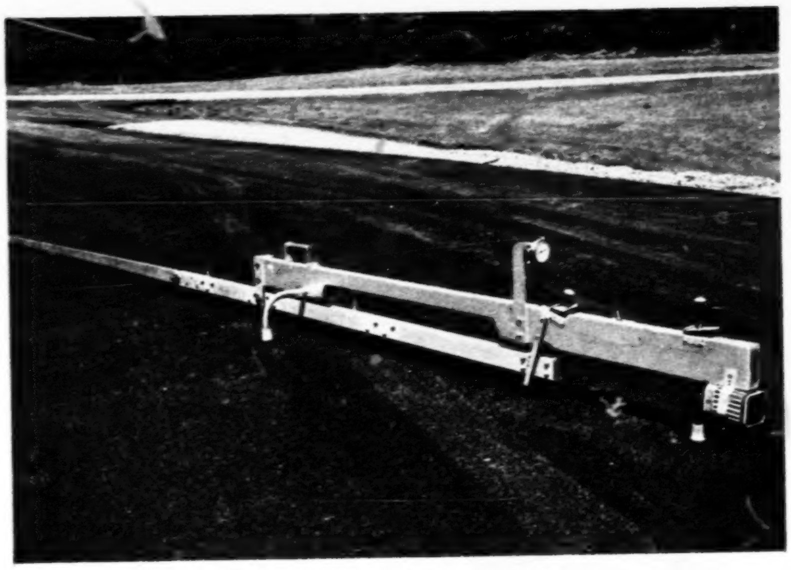


Figure VI-14—Benkelman beam

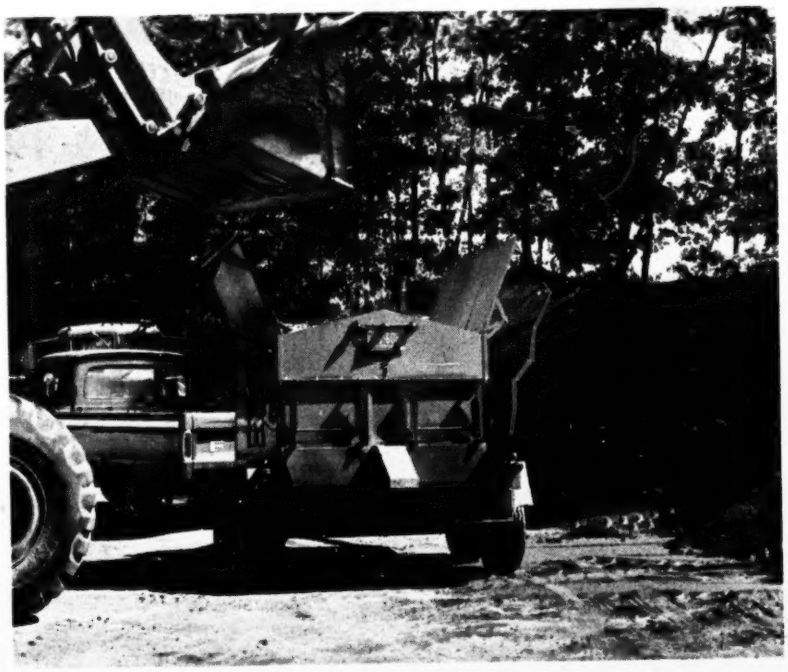


Figure VI-15—Stockpile-mix heater

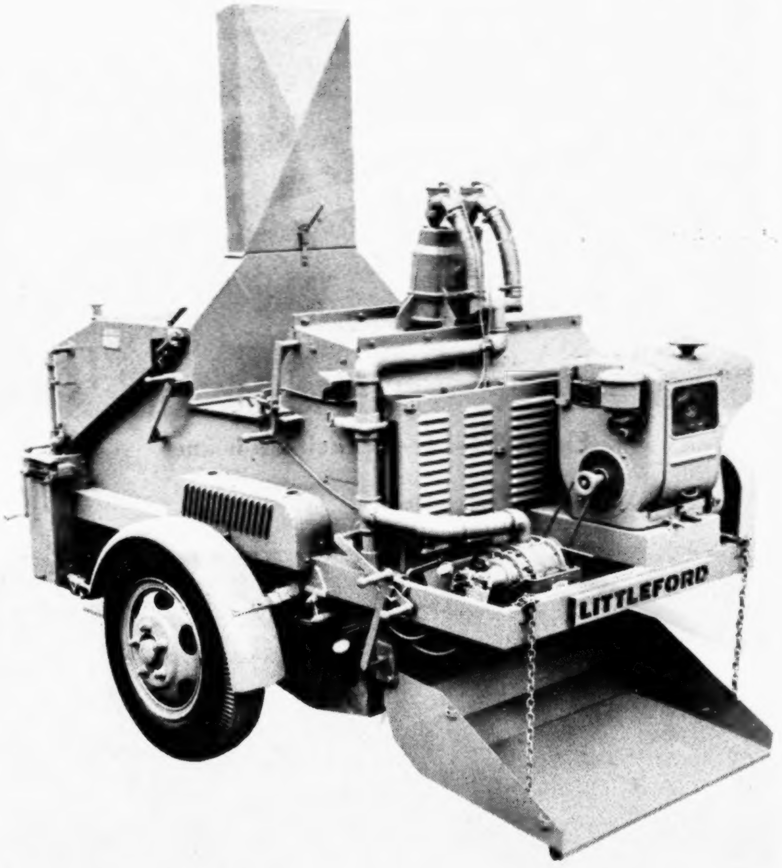

LITTLEFORD

Figure VI-16—Small portable mixer

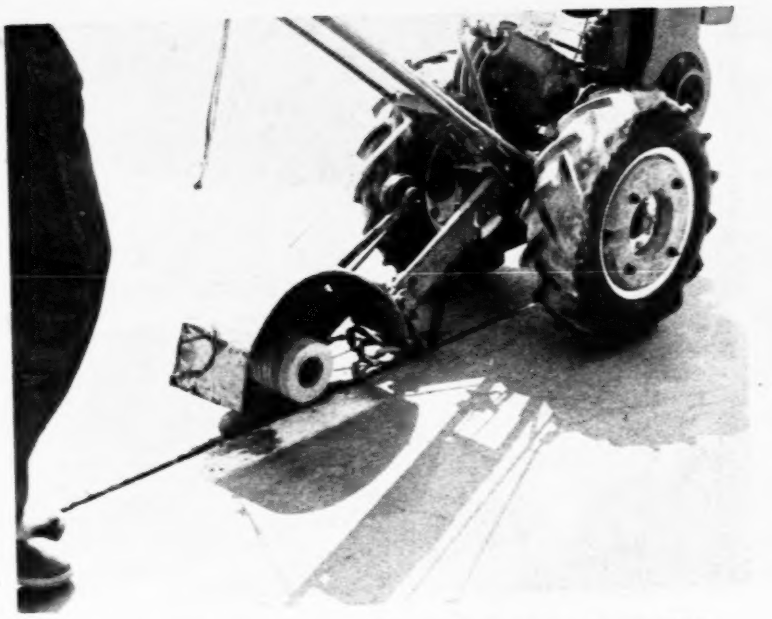


Figure VI–17—Power router (*Photo courtesy Ohio Highway Department*)

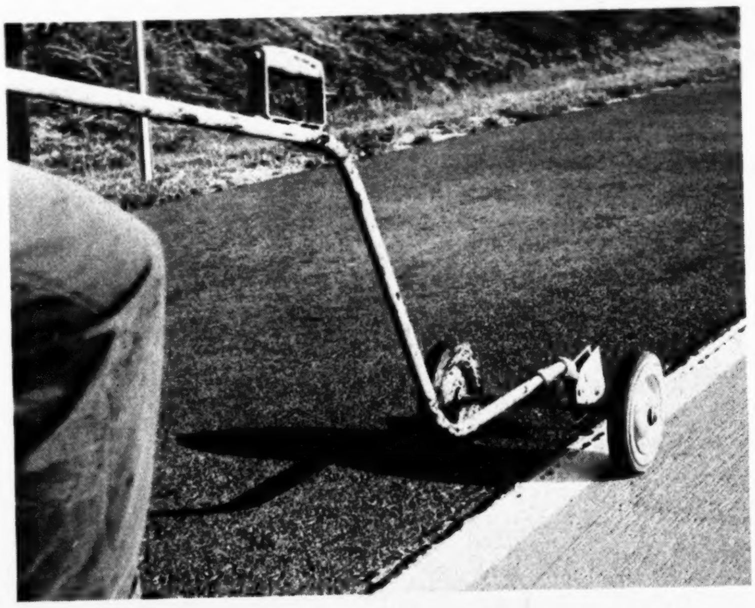


Figure VI–18—Shop-made joint-filling device (*Photo courtesy Virginia Department of Highways*)

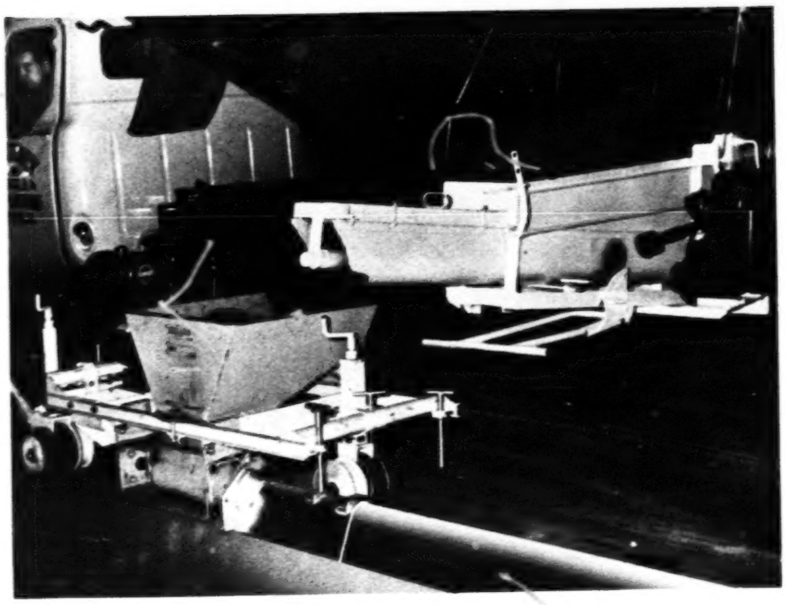


Figure VI–19—Asphalt curb machine

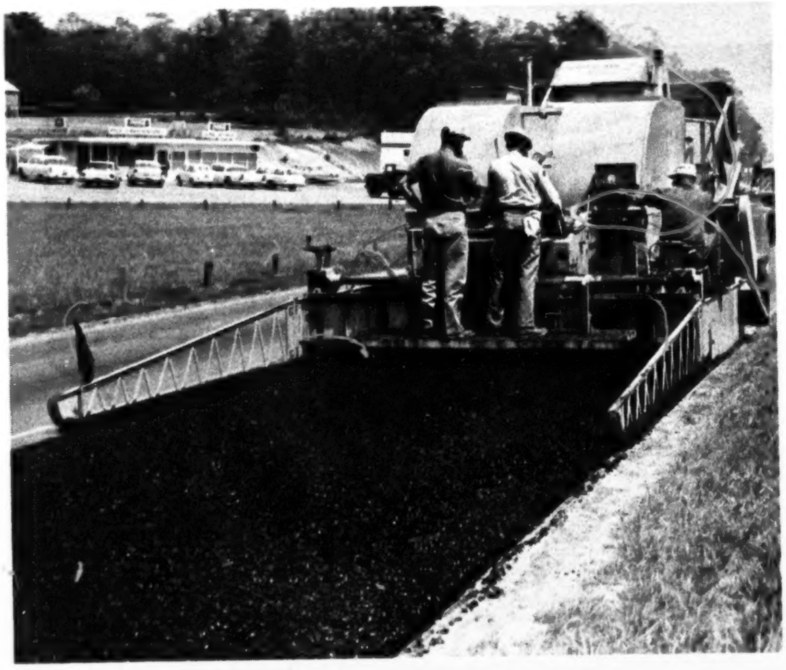


Figure VI–20—Asphalt travel plant

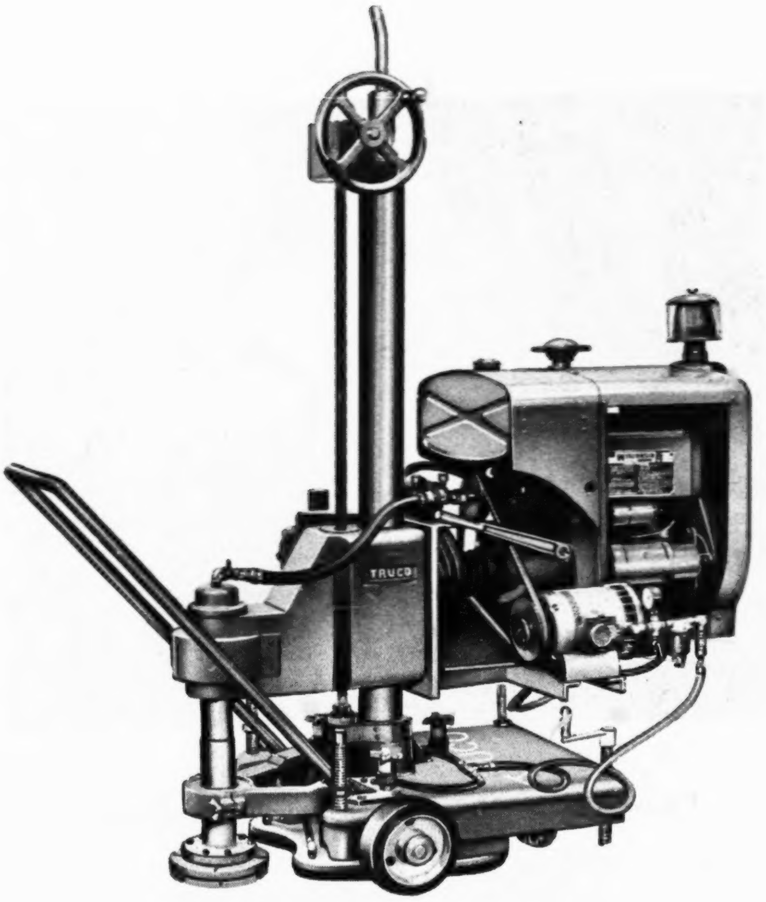


Figure VI–21—Core-drilling machine

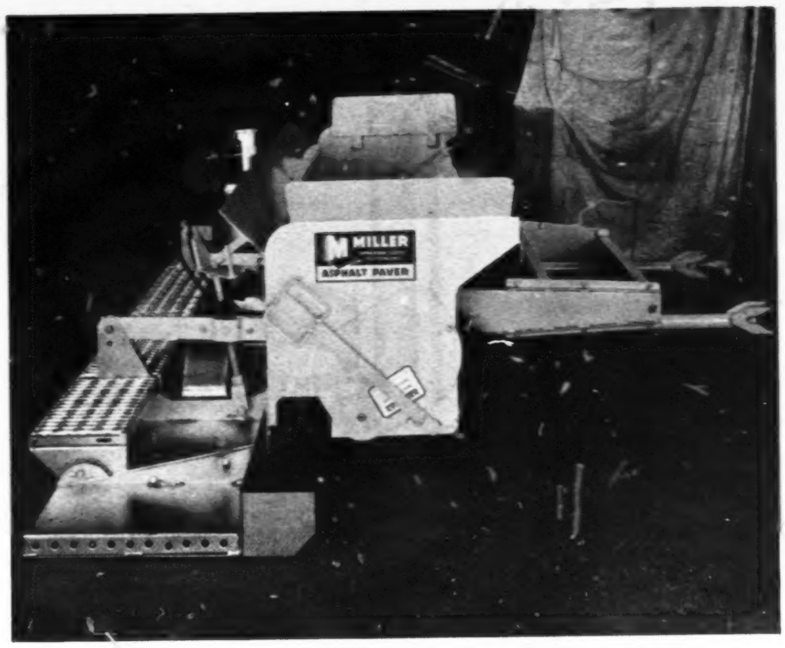

MILLER
ASPHALT PAVER

Figure VI–22—Maintenance asphalt mix spreader

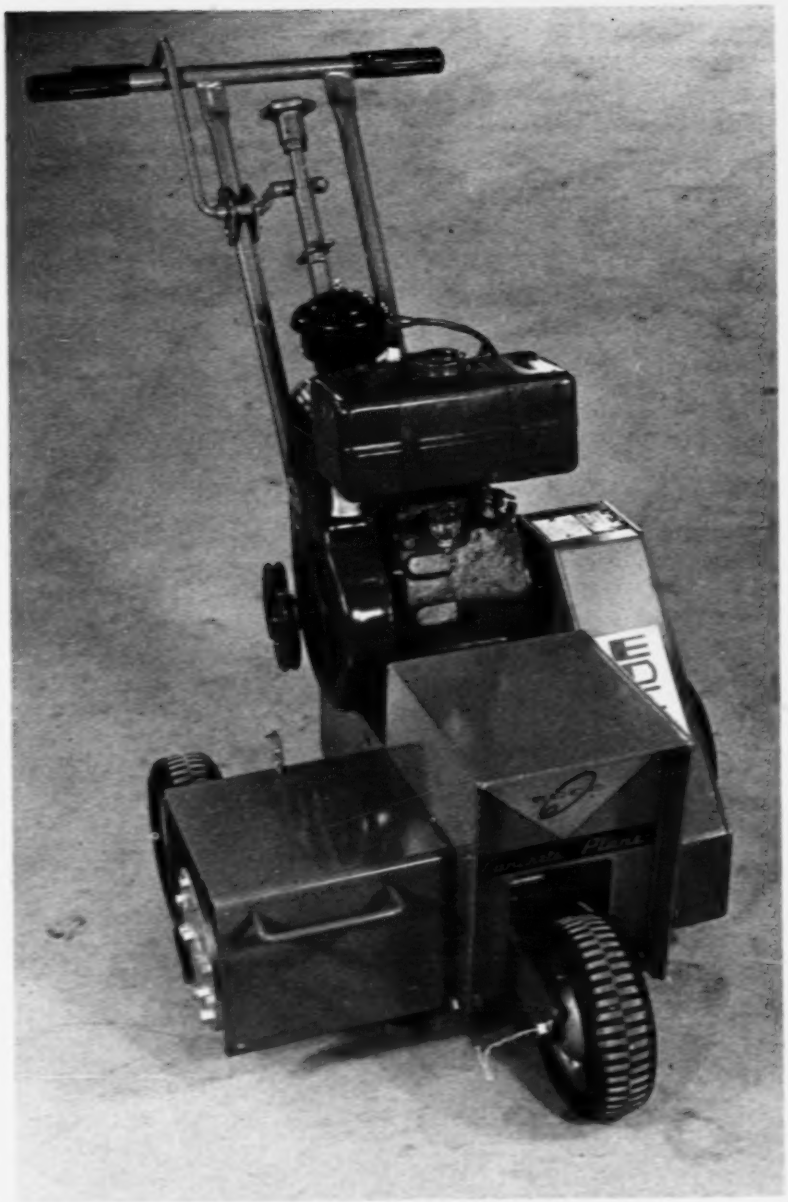


Figure VI-23—Pavement grinder

Appendix A

SUGGESTED SPECIFICATIONS FOR STOCKPILE PATCHING MIXTURES

Specification PM-2

PLANT-MIXED ASPHALT STOCKPILE MAINTENANCE MIXTURES

A.01 SCOPE—Furnish stockpile asphalt maintenance mixture as specified.

A. General Requirements

A.02 EQUIPMENT—The equipment shall include an asphalt mixing plant designed, coordinated, and operated to produce a uniform mixture within the job-mix tolerances.

A.03 SAMPLES—Samples for all materials proposed for use under these specifications shall be submitted to the engineer for test and analysis. The material shall not be used until it is approved by the engineer.

Sampling of asphaltic materials shall be in accordance with the latest revision of AASHO Designation T 40 (ASTM Designation D 140). Sampling of mineral aggregate shall be in accordance with the latest revision of AASHO Designation T 2 (ASTM Designation D 75).

A.04 METHODS OF TESTING—

(1) Asphaltic materials will be tested by the meth-

ods of test of the American Association of State Highway Officials (AASHO). If an AASHO method of test is not available, the American Society for Testing and Materials (ASTM) method will be used.

(2) Mineral aggregates will be tested by one or more of the following methods of test of the American Association of State Highway Officials (AASHO). If an AASHO method of test is not available, the American Society for Testing and Materials (ASTM) method will be used.

METHODS OF TESTING AGGREGATE MATERIALS

Characteristic	Method of Test	
	AASHO	ASTM
Abrasion of Coarse Aggregate, Los Angeles Machine	T 96	C 131
Sieve Analysis, Fine and Coarse Aggregates	T 27	C-136
Unit Weight of Aggregate	T 19	C 29
Sand Equivalent	T 176	—

B. Materials

A.05 ASPHALT—The asphalt shall be MC-250, MC-800, SC-250, SC-800, SM-K or CM-K, as specified by the engineer prior to letting the contract. The grade of asphaltic material specified shall meet the requirements for that grade in the applicable table of *Specifications for Asphalt Cements and Liquid Asphalts,* Specification Series No. 2 (SS-2), The Asphalt Institute.

A.06 MINERAL AGGREGATE—The mineral aggregate shall be crushed stone, crushed or uncrushed gravel, slag, sand, stone or slag screenings, mineral dust or a combination of any of these materials meeting one of the gradations shown below:

MINERAL AGGREGATE GRADATIONS

Sieve Sizes	Grading IVa	Grading IVb	Grading IVc
1 Inch	—	—	100
¾ inch	—	100	80–100
½ inch	100	80–100	—
⅜ inch	80–100	70–90	60–80
No. 4	55–75	50–70	48–65
No. 8	35–50	35–50	35–50
No. 30	18–29	18–29	19–30
No. 200	4–10	4–10	0–8

C. Construction

A.07 PREPARATION OF MIXTURE — Coarse and fine aggregate shall be fed into the plant in the proportions required to provide a total aggregate conforming with the grading specified in Article A.06. The aggregate shall be free from visible moisture at the time of mixing. The asphalt shall be applied at the rate and at the temperature specified by the engineer to produce a final mixture containing from 4 to 6 percent liquid asphalt by weight of total mix. The mineral aggregate and the asphalt shall be mixed thoroughly until all aggregate particles are completely coated.

A.08 STOCKPILING—The finished mixture shall be stockpiled on a platform of two (2) inch plank or other approved level storage space. When payment is to be made upon a cubic yard basis the stockpile shall be shaped to facilitate accurate volume measurement.

A.09 METHOD OF MEASUREMENT—The quantities to be paid for will be as follows:

Weight Basis—Total number of tons of asphalt maintenance mixture delivered to the stockpile.

Volume Basis—Total number of cubic yards of asphalt maintenance mixture as measured in the stockpile.

A.10 BASIS OF PAYMENT—The quantities measured as described in Article A.09 will be paid for at the contract unit price bid for this item. Payment will be in full compensation for furnishing, mixing, hauling, and stockpiling the mixture and for all labor and use of equipment, tools, and incidentals necessary to complete the work in accordance with these specifications.

Important Notice to the Engineer

(1) *Selection of Asphalt*—The following may be used as a guide for selecting the type and grade of asphalt for the stockpile mixture:

MC-250—For immediate use under hot or moderate weather conditions, or for use within a short time after stockpiling.

MC-800—For use within short time after stockpiling.

SC-250—For long period storage in hot, dry climates.

SC-800—For long period storage.

SM-k—Mix can be designed for use within a short time after stockpiling or for long storage period.

CM-K—Mix can be designed for use within a short time after stockpiling or for long storage period.

(2) *Amount of Asphalt*—The amount of asphalt required for the aggregate grading specified in Article A.06 will normally be in the range of 4 to 6 per cent by weight of total mix.

Specification RM-4

MIXED-IN-PLACE ASPHALT STOCKPILE MAINTENANCE MIXTURES

A.11 SCOPE—Furnish stockpile asphalt maintenance mixture as specified.

A. General Requirements

A.12 EQUIPMENT—The equipment includes travel mixers; rotary mixers; motor graders; and an asphalt pressure distributor meeting the following requirements:

> The pressure distributor shall be designed and operated to distribute the asphaltic material in a uniform spray without atomization.
>
> The distributor shall be equipped with a bitumeter having a dial registering feet of travel per minute. The dial shall be visible to the truck driver so that he can maintain the constant speed required for application at the specified rate.
>
> The pump shall be equipped with a tachometer having a dial registering gallons per minute passing through the nozzles. The dial shall be readily visible to the operator.
>
> Means for indicating accurately the temperature of the asphaltic material in the distributor at all times shall be provided. The thermometer well shall not be in contact with, or close to, a heating tube.
>
> The normal width of application of the spray bar shall not be less than 12 feet, with provision for the application of lesser width when necessary. A hose and spray nozzle attachment shall be provided for applying asphaltic material to patches and areas inaccessible to the spray bar.

The distributor shall be equipped with heating attachments and the asphaltic material shall be circulated through the spray bar during the entire heating process.

Multiple-blade drags or other equipment may be used in addition to or in lieu of the specified mixing equipment when approved by the engineer.

A.13 SAMPLES—If any portion of the in-place road materials are to be used in the construction the engineer will furnish the contractor with the test results and improvement requirements, if any, for the in-place materials. Samples of all other materials proposed for use under these specifications shall be submitted to the engineer for test and analysis. The material shall not be used until it is approved by the engineer.

Sampling of asphaltic materials shall be in accordance with the latest revision of *Sampling Asphalt Products for Specification Compliance,* IS-133, The Asphalt Institute. Sampling of mineral aggregate shall be in accordance with the latest revision of AASHO Designation T 2 (ASTM Designation D 75).

A.14 METHODS OF TESTING—

(1) Asphaltic materials will be tested by the methods of test of the American Association of State Highway Officials (AASHO). If an AASHO method of test is not available, the American Society for Testing and Materials (ASTM) method will be used.

(2) Mineral aggregates will be tested by one or more of the following methods of test of the American Association of State Highway Officials (AASHO). If an AASHO method of test is not available, the American Society for Testing and Materials (ASTM) method will be used.

METHODS OF TESTING AGGREGATE MATERIALS

Characteristic	Method of Test	
	AASHO	ASTM
Abrasion of Coarse Aggregate, Los Angeles Machine	T 96	C 131
Sieve Analysis, Fine and Coarse Aggregates	T 27	C 136
Unit Weight of Aggregate	T 19	C 29
Sand Equivalent	T 176	—

B. Materials

A.15 ASPHALT—The asphalt shall be MC-250, MC-800, SC-250, SC-800, SM-K, or CM-K, as specified by the engineer prior to letting the contract.

(1) The grade of asphaltic material specified for use shall meet the requirements for that grade in the applicable table of *Specifications for Asphalt Cements and Liquid Asphalts,* Specification Series No. 2 (SS-2), The Asphalt Institute.

(2) For spraying applications, the specified temperature will be such that the asphalt viscosity is within the range of 50-200 centistokes, kinematic viscosity (25-100 seconds, Saybolt Furol). The engineer will specify the temperature at which the material shall be used.

A.16 MINERAL AGGREGATE—The mineral aggregate shall be crushed stone, crushed or uncrushed gravel, slag, sand, stone screenings, mineral dust or a combination of any of these materials meeting one of the gradations shown below:

MINERAL AGGREGATE GRADATIONS

Sieve Size	Percent Passing, by Weight		
	Grading IVa	Grading IVb	Grading IVc
1 inch	—	—	100
¾ inch	—	100	80–100
½ inch	100	80–100	—
⅜ inch	80–100	70-90	60–80
No. 4	55–75	50–70	48–65
No. 8	35–50	35–50	35–50
No. 30	18–29	18–29	19–30
No. 200	4–10	4–10	0–8

C. Construction

Alternate 1—Travel Mixing

A.17 PREPARATION OF MIXTURE—Coarse and fine aggregate shall be deposited in a single windrow in the proportions required to provide a total aggregate conforming with the grading specified in Article A.16. Unless the travel mixer is equipped to measure and apply asphalt during the mixing operation, the windrow shall be flattened and the application shall be made with the asphalt distributor. The aggregate shall be free from visible moisture at the time of mixing. The asphalt shall be applied at the temperature and rate specified by the engineer to produce a final mixture containing from 4 to 6 per cent liquid asphalt by weight of total mix. The mineral aggregate and the asphalt shall be mixed thoroughly until all aggregate particles are completely coated.

Alternate 2—Blade Mixing

A.18 PREPARATION OF MIXTURE—

(1) Coarse and fine mineral aggregate shall be deposited in a single windrow in the proportions required

to provide a total aggregate conforming with the grading specified in Article A.16. After the proportions of coarse and fine aggregate are adjusted, the total loose aggregate shall be mixed thoroughly with a motor grader. It shall then be bladed into a single truncated windrow of uniform cross-section for measurement and adjustment as may be directed by the engineer.

(2) Immediately prior to application of the asphalt, the windrow of mixed aggregate shall be bladed to a uniform cross-section approximately two (2) inches thick. If damp, it shall first be bladed back and forth until surface dry. Upon the layer of graded aggregate, the asphalt shall be applied uniformly with the asphalt distributor at the temperature and at the rate specified by the engineer. The aggregate and asphalt shall be mixed as described in paragraph (3), following. Successive treatments of asphalt shall then be applied and mixed in the quantities, not exceeding one-half (½) gallon per square yard each, directed by the engineer.

(3) The motor grader shall follow the distributor immediately after each application of asphalt and shall continue to operate on the treated strip until all free asphalt is mixed into the aggregate. After the aggregate has received its total application of asphalt, mixing shall continue until a thoroughly uniform mixture is produced. If, before the process is completed, the mixture should become wet, the mixing operation shall be continued until it dries out. After final mixing the material shall be brought to a single windrow.

A.19 STOCKPILING—The finished mixture shall be stockpiled on a platform of two (2) inch plank or other approved level storage space. When payment is to be made upon a cubic yard basis the stockpile shall be shaped to facilitate accurate volume measurement.

A.20 METHOD OF MEASUREMENT—The quantities to be paid for will be as follows:

Weight Basis—Total number of tons of asphalt maintenance mixture delivered to the stockpile.

Volume Basis—Total number of cubic yards of asphalt maintenance mixture as measured in the stockpile.

A.21 BASIS OF PAYMENT—The quantities measured as described in Article A.20 will be paid for at the contract unit price bid for this item. Payment will be in full compensation for furnishing, mixing, hauling, and stockpiling the mixture and for all labor and use of equipment, tools, and incidentals necessary to complete the work in accordance with these specifications.

Important Notice to the Engineer

(1) *Selection of Asphalt*—The following may be used as a guide for selecting the type and grade of asphalt for the stockpile mixture:

MC-250—For immediate use under hot or moderate weather conditions, or for use within short time after stockpiling.
MC-800—For use within short time after stockpiling.
SC-250—For long period storage in hot, dry climates.
SC-800—For long period storage.
SM-K—Mix can be designed for use within a short time after stockpiling or long storage period.
CM-K—Mix can be designed for use within a short time after stockpiling or for long storage period.

(2) *Amount of Asphalt*—The amount of asphalt required for the aggregate grading specified in Article A.16 will normally be in the range of 4 to 6 per cent by weight of total mix.

(3) *Equipment*—The blade-mixing portion of these specifications is written to require a motor grader for the mixing process. If other equipment, such as disk harrows and multiple blade drags, must be used they should be added in Articles A.12, A.18 (1) and A.18 (3).

Appendix B

METHOD OF TEST FOR MEASURING DEFLECTIONS OF ASPHALT PAVEMENT STRUCTURES WITH THE BENKELMAN BEAM

B.01 SCOPE—This method of test covers a procedure for measuring static rebound deflections of an asphalt pavement under standardized axle load, tire size, and tire pressure.

B.02 EQUIPMENT—The equipment shall include the following:

(1) U.S. Bureau of Public Roads type Benkelman Beam having the following dimensions

- (a) Length of probe arm from pivot to probe point = 8 ft. 0 in.
- (b) Length of measurement arm from pivot to dial = 4 ft. 0 in.
- (c) Distance from pivot to front legs = 0 ft. 10 in.
- (d) Distance from pivot to rear legs = 5 ft. 5½ in.
- (e) Lateral spacing of front support legs = 1 ft. 1 in.

(2) Five-ton truck with 18,000-pound rear axle load equally distributed in two wheels, each with dual tires. The tires shall be 10.00x20, 12-ply inflated to a pressure of 80 psi. The use of tires with tubes and rib treads is recommended.

(3) Tire pressure measuring gauge.

(4) Thermometer, 0-140°F with 1-degree divisions.

B.03 PROCEDURE—

(1) Select and mark a point to be tested in the outer wheel path.
(2) Center the dual tires of the right rear wheel of the truck above the selected point.
(3) Insert the probe of the Benkelman Beam between the dual tires and place the probe point over the selected test point.
(4) Remove the locking pin from the beam and drop the probe point to the pavement. Adjust the rear legs so that the plunger of the beam is in contact with the dial gauge stem. Adjust the dial gauge to read approximately 0.4 inch.
(5) Start buzzer.
(6) Record initial reading of dial when dial needle stops moving.
(7) Move truck forward about 30 feet.
(8) Record final reading of dial when the dial needle stops moving.

B.04 CALCULATIONS — Subtract the final dial reading from the initial dial reading. The difference multiplied by 2 is the actual pavement deflection.

B.05 MISCELLANEOUS — Obtain air temperature and approximate pavement temperature.

B.06 REPORT—The report shall include the following:

(a) Test location
(b) Deflection
(c) Air and pavement temperatures.

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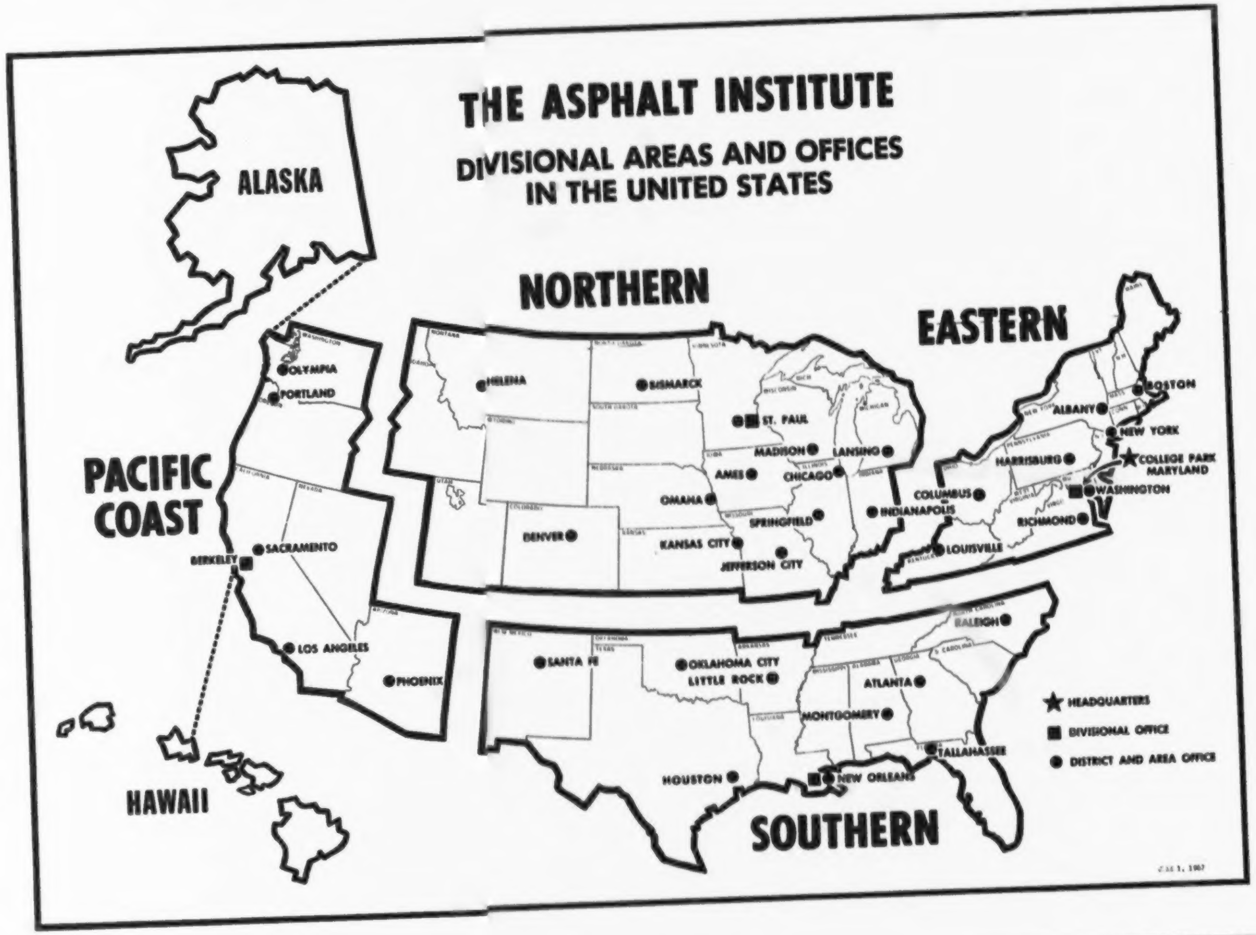
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